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Attrition and Body Mass Index Change in Pediatric Weight Management: The Predictive Value of Demographic and Mental Health Variables

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Attrition and Body Mass Index Change in Pediatric Weight Management: The Predictive Value of Demographic and Mental Health Variables

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Child and adolescent obesity has increased dramatically in the last few decades, and remains a pressing health concern in the United States. Responding to the problem of obesity in youth has been a challenge, as body mass index (BMI) change is difficult to attain, and attrition from pediatric weight management programs is often very high. The purpose of the current study was to identify demographic and mental health variables that can predict attrition and BMI change in a pediatric weight management program using multiple linear regression and binary logistic regression. Participants were children and adolescents with obesity 6-18 years of age and their parents living in the central Texas area and participating the a hospital-based multidisciplinary pediatric weight management program. Results provided several significant findings. Rates of attrition from the intervention were similar to findings from prior research. No study variables significantly predicted dropout prior to the third visit. However, parent's preferred language, taking psychiatric medication at the first visit, and symptoms of inattention were all significant predictors of dropout prior to the fourth visit. In paired-samples *t*-tests, unstandardized BMI scores increased significantly from first to last visit, while BMI *z*-scores decreased significantly. Average time between visits significantly predicted

unstandardized BMI change and BMI *z*-score change in this sample. Last visit number was also a significant predictor of unstandardized BMI change. Implications, limitations, and areas of future research are discussed.

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Chapter 1: Introduction

According to experts, young people are considered to have obesity if they have a body mass index (BMI) at the 95th percentile or higher for age and sex, with norms based on a reference group from the 1970s through the 1990s (Barlow and the expert committee, 2007). Childhood and adolescent obesity has increased dramatically in the last few decades. Recent government estimates report an obesity rate of about 17% among U.S. children and adolescents, with Black and Hispanic youth experiencing significantly higher rates of obesity than their White or Asian peers (Ogden, Carroll, Flegal, & Kit, 2014). Fortunately, these data also show that the overall rate of youth obesity has leveled off since about 2003, suggesting that concerted efforts to address the U.S. obesity problem may be having an effect. Despite these promising findings, until there is a significant reduction in rates of obesity in youth, clinicians and researchers must continue to focus their efforts on addressing childhood and adolescent obesity, as it poses a serious threat to the current and future health of the US population.

Physical and Mental Health Consequences of Obesity in Youth

Physical Health

The adverse health effects of obesity in youth are well documented. Immediate complications include cardiovascular risk factors (e.g., elevated blood pressure and cholesterol), asthma, type 2 diabetes, obstructive sleep apnea, and orthopedic problems (Deckelbaum & Williams, 2001; Ievers-Landis & Redline, 2007; Must & Strauss, 1999; Reilly et al., 2003). Among American youth ages 10 to 19, prevalence of type 2 diabetes increased from 3.4 to 4.6 cases per 10,000 individuals between 2001 and 2009 (Dabelea et al., 2014), and it is projected that the prevalence of type 2 diabetes in youth will

increase 178% from about 2010 to 2050 (Imperatore et al., 2012). Obesity in childhood and adolescence is also a strong predictor of adult obesity (Deckelbaum & Williams, 2001), so youth with obesity are at high risk for later adult comorbidities, including type 2 diabetes, hypertension, sleep apnea, orthopedic problems, and premature death (Dietz, 1998; Reilly et al., 2003). Among adolescents seeking obesity treatment, about 30% present with three or more serious cardiovascular risk factors, a combination often referred to as 'metabolic syndrome' and thought to be indicative of serious risk for cardiovascular health problems (Wickham et al., 2009). Childhood and adolescent obesity is not a cosmetic condition, as it poses a serious threat to the health of American youth and their chances of leading healthy adult lives.

Internalizing Problems in Youth With Obesity

There is some evidence from cross-sectional research suggesting that individuals with obesity may have increased levels of internalizing problems, such as depression and anxiety, though findings are somewhat mixed. Some studies have found small correlations between depression and obesity (Blaine, 2008; Markowitz, Friedman, & Arent, 2008), while other findings do not support such an association (Goodman & Whitaker, 2002). There is somewhat stronger evidence for longitudinal associations between depression and obesity, with depression at baseline being independently associated with later obesity, and vice versa. A meta-analysis encompassing over 58,000 participants found that people with obesity at baseline were at a 55% increased risk for depression at follow-up for adults, while adults and young people who were depressed at baseline were at a 58% increased risk for later obesity (Luppino et al., 2010).

Fewer studies have looked at depression or internalizing problems in childhood and adolescence specifically, suggesting that more research is needed on this topic. Youth

with obesity do face weight-based stigmatization in the form of mistreatment and negative stereotyping from peers, educators, and medical professionals, which could contribute to the development internalizing problems such as anxiety and depression (Gray, Kahhan, & Janicke, 2009; Puhl & Brownell, 2006; Puhl & Latner, 2007; Strauss & Pollack, 2003). Youth with obesity have been found to have significantly lower self-esteem, higher body dissatisfaction, and more difficulties in interpersonal relationships when compared to peers without obesity, though these associations are sometimes weaker for boys and for those not seeking treatment to manage their weight (Braet, Mervielde, & Vandereycken, 1997; French, Story, & Perry, 1995; Merten, Wickrama, & Williams, 2008; Puhl & Latner, 2007; Strauss, 2000). One large study of adolescents found that depression and obesity were not correlated at baseline, and while depressed mood at baseline independently predicted obesity after one year, obesity at baseline did not independently predict depression at follow up (Goodman & Whitaker, 2002). Looking across development, internalizing problems and obesity appear to have little association prior to age seven, but a small and strengthening association as children age into adolescence (Bradley et al., 2008). Thus, preliminary findings suggest that internalizing problems are associated with obesity starting in childhood, and there may be a bidirectional relation between them, though more research is needed to examine these links in young people because findings are mixed.

Externalizing Problems and ADHD in Youth With Obesity

A growing body of research has also looked at the links between externalizing problems, attention-deficit/hyperactivity disorder (ADHD), and obesity. A nationally representative survey revealed that youth with ADHD were twice as likely to be overweight or obese when compared to peers without ADHD (Erhart et al., 2012).

Among more than 150,000 American youth it was shown that unmedicated ADHD in childhood predicts higher later BMI, while ADHD treated with stimulant medications predicted slower BMI growth early on, but a BMI rebound in adolescence (Schwartz et al., 2014). Further, relative to peers without obesity, youth with chronic obesity appear to be at a two and a half-fold increased risk for oppositional-defiant disorder (ODD) (Mustillo et al., 2003). When compared to diabetic controls, children and adolescents getting treatment for obesity scored higher on an overall measure of externalizing symptoms (Vila et al., 2004), though other cross-sectional studies have found no or small associations between externalizing problems and obesity (Pine, Cohen, Brook, & Coplan, 1997; Van Vlierberghe & Braet, 2007). There is preliminary evidence suggesting that the association between obesity and externalizing problems may disproportionately affect minority youth, highlighting the need for studying the links between mental health and obesity in diverse samples of youth. For example, while the BMI disparity between externalizing and non-externalizing children seems to remain stable across time for White children, this disparity becomes more pronounced over time for their minority peers (S. Anderson, He, Schoppe-Sullivan, & Must, 2010). In sum, a number of studies have demonstrated links between obesity in youth, externalizing problems, and ADHD. Though not uniformly strong, research suggests that ADHD and externalizing problems are associated with an increased risk of concurrent or later obesity, with potential moderating effects of ethnic background and medication use. Again, however, more research is needed to clarify these findings.

Causal Mechanisms Linking Youth Obesity and Mental Health

A number of plausible hypotheses have been suggested to explain associations between youth obesity and mental health difficulties. If substantiated, these mechanisms

could reveal how influencing mental health might affect obesity, and vice versa. Regarding internalizing problems, Luppino et al. (2010) outlined a number of possible causal pathways from obesity to depression, including obesity as a chronic inflammatory state, dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, brain alterations caused by obesity-related diabetes, increased pain, and self-perception within a rejecting cultural context. These authors also discussed mechanisms by which depression could lead to obesity, including long-term HPA axis disturbance, interactions between insulin levels and body fat storage, unhealthy changes in lifestyle, and antidepressant use.

For ADHD, a study looking at shared genetic markers found little evidence for genetic links between this disorder and obesity (Albayrak et al., 2013). However, a more promising causal model indicates that the presence of strongly reward-driven eating, combined with reduced inhibitory control, drives an interaction between reward sensitivity, impulsivity, and obesity (Appelhans, 2009). This 'reward deficiency' model is supported by findings that low brain dopamine levels predict overeating and obesity, and that artificially increasing dopamine levels results in reduced feeding (Liu, Li, Yang, & Wang, 2008). It has also been suggested that inattention may interfere with individuals' ability to adhere to regular patterns of eating (Cortese et al., 2008), though this link remains speculative. Although far from conclusive, there are convincing arguments for causal links between obesity and mental health challenges. These links may help to explain observed associations between obesity and these mental health, and they may guide interventions toward targeting the fundamental mechanisms behind these links.

INTERVENTIONS FOR OBESITY IN YOUTH: SUCCESSES AND CHALLENGES

Intervention Structure and Effectiveness

In 1997, a committee of national experts was assembled to provide practice recommendations for clinicians based on the latest scientific evidence and clinical expertise in the field of pediatric obesity. In a seminal 1998 document, recommendations from this committee were presented to guide the evaluation and treatment of pediatric obesity in medical settings, and this document was updated in 2007 (Barlow & Dietz, 1998; Barlow & The Expert Committee, 2007). These recommendations remain highly influential. Children's hospitals in particular have responded to this guidance by establishing 'stage three' intervention programs, which employ structured multidisciplinary interventions in hospital settings (Children's Hospital Association, 2014).

Research reveals that multidisciplinary weight management programs for children and adolescents are often effective, with behavioral interventions targeting lifestyle change using a structured, family-based approach resulting in modest, but clinically significant reductions in BMI (Oude Luttikhuis et al., 2009; Snethen, Broome, & Cashin, 2006). However, best-practice recommendations are expansive, providing broad principles rather than detailed guidance regarding specific intervention strategies. Another gap in the research exists when it comes to how well interventions serve ethnic minority populations. Most of the literature examining obesity interventions for children and adolescents is derived from samples of White, middle-class individuals (Oude Luttikhuis et al., 2009). Thus, there is uncertainty regarding how well the recommended treatment paradigms work for minority and poorer youth. Significant challenges for researchers attempting to study pediatric weight management programs include assessing the effectiveness of existing programs, advancing research that leads to specific treatment

recommendations, and ensuring that this literature base is inclusive of ethnic minority populations who are disproportionately affected by obesity.

Predicting Attrition from Pediatric Weight Management

In order to build an evidence-base that will allow practitioners to enhance interventions and improve outcomes, some researchers have attempted to identify patient characteristics that predict attrition from weight management programs. Reducing patient attrition is one way in which pediatric weight management could have a broader impact on pediatric obesity. Studies examining outcomes in pediatric weight management often only include participants who completed all or most of an intervention, but in order for programs to reach as many young people as possible, the problem of attrition will need to be addressed. Thus, further research must be conducted so that those responsible for running pediatric weight management programs can understand the reasons youth do not complete treatment and identify youth who are at risk for dropout.

Overall, attrition rates for pediatric weight management programs reported across the literature are variable, and often quite high, ranging from about 4 to 83%, with a median attrition rate of 37% (Dhaliwal et al., 2014). Similarly, in one large hospital-based program, out of 2,240 scheduled appointments, 37% were not attended (Halvorson & Skelton, 2012). Early evidence suggests that youth who discontinue treatment tend to be older, have lower BMI *z*-scores at baseline, and poorer school performance (Skelton, Goff, Ip, & Beech, 2011). Other individuals identified as being at-risk for dropout include Medicaid recipients, Black youth, and those who self-report more symptoms of depression and lower self-concept (Zeller et al., 2004). The finding that Black youth were more likely than youth from other ethnic backgrounds to leave treatment has been replicated elsewhere (Tershakovec & Kuppler, 2003). Further research can help clarify

which patient characteristics are most helpful in predicting attrition from pediatric weight management so that special efforts can be made to retain these youth in treatment.

Predicting Weight Change in Pediatric Weight Management

Among those who do complete treatment, some studies have attempted to identify predictors of weight or BMI change in weight management programs. Among adults there are very mixed findings, but the most reliable predictors of treatment success seem to be fewer prior weight loss attempts, autonomous self-motivation, and higher pre-treatment BMI, while eating pathology and depression or mood problems do not tend to predict outcomes (Teixeira, Going, Sardinha, & Lohman, 2005). Among samples of youth some evidence seems to show a link between mental health problems, including internalizing problems and the presence of a psychiatric diagnosis, and weight change (Epstein, Wisniewski, & Weng, 1994; Van Vlierberghe & Braet, 2007), while other evidence does not (Braet, 2006). Among Latino adults, acculturation seems to be associated with greater obesity risk in general (Pérez-Escamilla & Putnik, 2007), though this association is not clear among youth, and acculturation or language preference has not yet been linked to outcomes in pediatric weight management. Overall, the question of which variables might predict outcomes in pediatric weight management remains an important one, and one which is largely unanswered. Additional research could reveal important variables related to weight change in interventions targeting obesity in youth.

THE PRESENT STUDY

Identifying variables that predict attrition and BMI change in pediatric weight management has the potential to inform better interventions by directing focus on these variables during program development. It could also improve existing interventions by helping clinicians to identify and intervene individually with patients who appear to be at

risk for poor outcomes or early dropout. The objective of the present study is to examine BMI change and attrition in a multidisciplinary pediatric weight management program, and to determine whether mental health and other patient characteristics are related to these outcomes. This study is unique in several ways. First, it includes a demographically diverse sample of youth and parents seeking treatment for pediatric obesity, thereby adding to the understanding of how well these programs serve minority populations. Second, the multidisciplinary, hospital-based pediatric weight management program being studied is representative of many programs across the US, as it is based on expert recommendations for stage three pediatric obesity interventions (Stages of Obesity Treatment, 2007). Finally, all variables in the present study could be easily and affordably derived from information gathered by clinicians in the field as part of regular practice. Therefore, results of this study may be applicable to the experience of clinicians across the United States, and could be easily translated into meaningful improvements in the assessment and treatment of pediatric obesity.

The following research questions guided this investigation:

- Do mental health variables predict BMI change, BMI *z*-score change, and attrition in a diverse sample of youth seeking treatment for obesity?
- Do easily gathered demographic variables, such as age, gender, insurance status, racial/ethnic background, and parent's preferred language predict BMI change, BMI *z*-score change, and attrition in pediatric weight management?

Chapter 2: Method

Intervention Program

Participants in this study were patients in the Activating Children Empowering Success (ACES) clinic, a hospital-based pediatric weight management program in central Texas. Prior to participating in ACES, participants were referred by a primary care provider. In order to be considered for treatment, youth had to have a BMI at or above the 95th percentile for age and sex and present with at least one medical comorbidity related to obesity, or have a BMI at or above the 99th percentile without any medical comorbidities. At the initial appointment, each youth, along with at least one parent or caregiver, attended an intake session that included a comprehensive evaluation by a pediatrician and a behavioral health specialist (i.e., licensed psychologist or licensed social worker).

At follow-up visits, each youth and his or her parent or caregiver consulted with a series of specialists, including a pediatrician, behavioral health specialist, registered dietitian, and athletic/recreation specialist, in order to set individualized health goals and assess progress. Typical interventions during these sessions included medical consultation with a pediatrician, fitness assessment and physical activity goal setting, nutrition consultation and goal setting, and behavioral health consultation focused on individual- and family-level behavior change. Additionally, families were provided with assistance (e.g., coupons, referrals, and information) as needed to help them gain access to community resources supporting family health. Bilingual (English and Spanish) staff and translation services were available for non-English speaking patient caregivers and family members. After the first follow-up visit, which was typically scheduled two weeks after initial intake, additional follow-up visits were scheduled at one to two month intervals as needed until either adequate progress was achieved, the family chose to

discontinue treatment, or it was determined that another intervention was more suitable. For the present study, participants were studied from intake until their third, fourth, or fifth appointment, whichever was last during the study period.

In addition to the above procedures, regular mental health/behavioral counseling was made available to clinic patients whose progress seemed to be affected by mental health or behavioral challenges. These services were provided by licensed psychologists, doctoral interns in psychology, or advanced doctoral trainees in psychology. The focus of treatment was individualized for each patient, and often included individual cognitive-behavioral therapy, parent training in behavior management, or family therapy. These services were provided with an understanding of the interrelated nature of behavioral health, family functioning, lifestyle choices, and physical health. Finally, some patients in the clinic also participated in clinic-related weekly group programs targeting obesity reduction in addition to their ACES clinic visits.

DATA COLLECTION

Data were collected through retrospective chart review of children and adolescents ages 6 to 18 who were patients in the ACES program. All patients who were active clinic patients between Fall, 2013 and Summer, 2015 were included in the study. This included patients who began their participation in the program prior to Fall, 2013 and were active at that time.

CLINICAL MEASURES

Patient Background Information

Age, gender, ethnic background/race, and parent's preferred language were assessed by self-report in a pre-treatment information packet completed by caregivers prior to their intake appointment. Where self-report data were missing, information was

extracted from electronic medical records and, in the case of preferred language, assessed by examining the language of intake forms parents requested. Patient age was coded in years, and gender was coded dichotomously (Male = 0, Female = 1). Subsidized versus non-subsidized insurance status was also coded dichotomously from patients' initial intake paperwork and electronic medical records (Private/Unsubsidized = 0, Medicaid/Subsidized or No Insurance = 1). In this clinic, ethnic background/race was assessed using an open-ended question, answered by caregivers, or was extracted from electronic medical records when not self-reported on intake paperwork. Responses were coded into dichotomous (dummy) variables in the following groups: White/Caucasian, Black/African American, Hispanic/Latino, or Other. The White/Caucasian group was used as a reference group in all analyses. Parent's preferred language was self-reported on intake paperwork or, when not self-reported, was coded by examining the language of forms requested by parents at intake. This variable was coded dichotomously (English Preferred = 0, Spanish or Both English and Spanish Preferred = 1).

Biometrics

At the beginning of each appointment, height and weight were measured by trained medical staff using a hospital-grade stadiometer and scale. BMI was calculated using the formula kilograms/meter^2. BMI was converted to a *z*-score (mean of zero, standard deviation of one) for some statistical analyses based on the most updated norms adjusted for age and sex (Kuczmarski et al., 2000).

Mental Health

The Pediatric Symptom Checklist – 17 (PSC-17) (Gardner et al., 1999) is a brief psychological screening tool designed for use with 4 through 15-year-old youth, though several studies have used the measure up to age 16 or 17 (Jutte, Burgos, Mendoza, Ford,

& Huffman, 2003; Murphy, Arnett, Bishop, Jellinek, & Reede, 1992; Richardson et al., 2010; Stoppelbein, Greening, Moll, Jordan, & Suozzi, 2012). Based on the 35-item Pediatric Symptom Checklist (PSC) (Jellinek et al., 1988), the PSC-17 is a 17-item parent-report psychosocial screening tool. The PSC-17 consists of Internalizing, Externalizing, and Attention subscales. The Internalizing and Attention subscales include five items each, while the Externalizing subscale includes seven items. Each item on the PSC-17 is scored 0 (never), 1 (sometimes), or 2 (often), indicating the frequency of each particular symptom. Recommended cutoff scores, which suggest that psychosocial dysfunction in a given area may be present, are five for the Internalizing subscale, seven for both the Externalizing and Attention subscales, and a total cutoff score of 15 (Gardner et al., 1999). An initial validation study of the PSC-17 found adequate internal consistency values, with Chronbach's Alpha values of .79 for Internalizing, .83 for Externalizing, .83 for Attention, and .89 for total score. Further, good agreement was found between the PSC-17 and other measures of psychosocial dysfunction (Gardner et al., 1999). The 35-item PSC was also recently endorsed by the National Quality Forum (NQF) after field testing (National Quality Forum, 2013). For the present study, the Internalizing, Externalizing, and Attention continuous subscales of the PSC-17 were used in all analyses.

Two additional mental health variables were included in analyses. Charts were reviewed to code whether the youth seeking treatment was taking psychiatric medications, such as stimulants or antidepressants, at the time of intake. This variable was coded dichotomously (0 = No Psychiatric Medications Reported, 1 = Psychiatric Medications Reported). Finally, patient records were examined to determine whether the patient received at least an initial appointment for mental health counseling within the clinic prior to their last visit in the study period, in addition to the mental health

counseling received in regular clinic visits. This was also coded dichotomously (0 = No counseling, 1 = At least one counseling visit).

DATA ANALYSIS

Descriptive statistics, including frequencies, means, minimums, maximums, and standard deviations, were used to describe the data and were examined to identify errors and outliers in the data that could lead to invalid findings. Variables examined using descriptive statistics included demographic characteristics, mental health scores, overall rate of attrition, time between visits, BMI change, and BMI *z*-score change over the observed course of treatment.

Attrition from the weight management program was defined as stopping intervention prior to completing three total sessions, including intake. A second attrition cut point of four sessions was also tested, as systematic reviews have not yet identified the ideal or minimum treatment length for effectiveness (Oude Luttikhuis et al., 2009), though 25 hours of intervention within a six month period has been suggested for achieving good outcomes (US Preventive Services Task Force, 2010). Binary logistic regression models were employed in order to test for significant predictors of attrition. In these models, attrition was entered as the dichotomous dependent variable (Retained = 0, Dropped = 1).

BMI *z*-score change was calculated for each patient by subtracting BMI *z*-score measured at the initial session from BMI *z*-score measured at the third, fourth, or fifth appointment, whichever was last within the study period. This resulted in change scores in which negative values indicated reductions in BMI *z*-scores (desired outcome), positive values indicated increases in BMI *z*-scores, and values of zero indicated no change in BMI *z*-scores. For patients who attended more than five appointments, fifth

appointment BMI *z*-score was used for the comparison. Simultaneous multiple regression models were employed in order to test for significant predictors of BMI *z*-score change. In order to control for variable length of treatment, last visit number (coded 3, 4, or 5 for the last session number) and average time between visits were entered as additional independent variables in the regression model. In this model, BMI *z*-score change was entered as a continuous dependent variable. The same independent variables were also entered into a regression model predicting unstandardized BMI change, as BMI *z*-score has been shown to have significant limitations for measuring adiposity change over short periods of time for youth with obesity (Cole, Faith, Pietrobelli, & Heo, 2005).

All analyses were performed using IBM SPSS Statistics, Version 24. This study was approved by Seton Hospitals Institutional Review Board.

Chapter 3: Results

PARTICIPANT CHARACTERISTICS

During the study period, a total of 213 patients attended at least one appointment at the clinic, met study criteria, and were included in analyses examining attrition (listwise $N = 176$). During the same period, a total of 164 patients attended at least three, four, or five appointments, and were included in analyses examining BMI and BMI *z*-score change. Of these patients, three were missing BMI *z*-score data, yielding a total sample size of 161 for examining BMI *z*-score change. There was considerable variability in average time between appointments, with time intervals ranging from 24.5 to 219.5 days ($M = 60.64$, $SD = 26.23$). Three patients were excluded from analyses due to their unusually long time (over one year) to reach three sessions. Study variable descriptive statistics are displayed in Table 1 and Table 2 below.

Table 1: Continuous Variable Descriptive Statistics.

Variable	BMI Change Sample (N=164)		Attrition Sample (N=213)	
	M	*SD*	*M*	*(SD)*
BMI *z*-score Change at Last Visit	-.027	.169		
BMI Change at Last Visit	.475	1.61		
Days Between Visits	60.60	26.24		
Age	11.15	2.91	11.16	2.95
PSC-17 Scores				
Total Score	9.89	6.13	9.93	5.97
Attention	3.61	2.48	3.65	2.43
Externalizing	3.39	2.94	3.45	2.92
Internalizing	3.12	2.57	2.95	2.49

Table 2: Dichotomous, Ordinal, and Dummy-Coded Variables for Attrition and BMI Change Samples.

Variable	BMI Change Sample (N=164)		Attrition Sample (N=213)	
	%	*N*	*%*	*N*
Dropped Out				
Before third Visit			33.3	71
Before fourth Visit			48.4	104
Last Visit Number				
Third	31.1	51		
Fourth	20.1	33		
Fifth	48.8	80		
Gender (Female)				
Male	52.4	86	55.4	118
Female	47.6	78	44.6	95
Race/Ethnicity				
White (reference variable)	19.5	32	21.6	46
Black/African American (Black)	9.1	15	9.4	20
Hispanic/Latino (Hispanic)	48.2	79	51.6	110
Other (Other)	12.2	20	8.9	19
Parent Preferred Language (Spanish)				
English	58.5	96	64.8	138
Spanish or No Preference	39.6	65	33.8	72
Insurance (Subsidized)				
Private Insurance	31.1	51	34.7	74
Subsidized or No Insurance	68.9	113	65.3	139
Counseling by Last Visit (Counseling)				
No Counseling	75	123		
Counseling	23.8	39		
Psych Med at Intake (Psych Med)				
No Psych Med	82.3	135	83.1	177
Psych Med	15.9	26	15.5	33

Note: Dichotomous variables are named to reflect the group coded 1; these names are shown in parentheses. Percentages may not sum to 100 due to missing data.

CORRELATIONS

Bivariate correlations were estimated in order to examine the associations between continuous study variables. There were several statistically significant ($p < .05$) correlations among variables in the sample of patients who attended at least three visits to the clinic. In this sample, the correlation between BMI *z*-score change and average time

between visits was positive and statistically significant (r = .213, p = .007), suggesting that more time between visits is associated with poorer BMI z-score change outcome. Unstandardized BMI score change was positively correlated with both last visit number (r = .167, p = .033) and average time between visits (r = .342, p < .001), and these correlations were statistically significant. Finally, all PSC-17 subscales were positively correlated, and these correlations were statistically significant. A correlation matrix for this sample is displayed in Table 3 below.

Table 3: BMI and BMI z-Score Change Sample Correlations.

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1. BMI z-score Change at Last Visit	1							
2. BMI Change at Last Visit	-	1						
3. Last Visit Number	-.058	.167*	1					
4. Average Time Between Visits	.213**	.342**	.144	1				
5. Age at First Visit	.137	-.017	-.003	.032	1			
6. PSC-17 Attention	.041	.025	-.041	.079	-.081	1		
7. PSC-17 Externalizing	.152	.095	.060	.051	-.107	.464**	1	
8. PSC-17 Internalizing	.085	.033	.123	.034	.157	.368**	.325**	1

There were also several statistically significant (p < .05) correlations among variables in the sample of patients who dropped out prior to the third or fourth visit. In this sample, age at first visit was positively correlated with the PSC-17 Internalizing subscale (r = .193, p = .007). Again, all PSC-17 subscales were positively correlated with one another. A correlation matrix for this sample is displayed in Table 4 below.

Table 4: Attrition Sample Correlations.

Variable	1.	2.	3.	4.	5.	6.	7.
1. Dropped Before 3rd Visit	1						
2. Dropped Before 4th Visit	-	1					
3. 1st Visit BMI *z*-Score	.040	.005	1				
4. Age at First Visit	.021	-.029	-.057	1			
5. PSC-17 Attention	.034	.043	.015	-.081	1		
6. PSC-17 Externalizing	.040	-.034	.016	-.084	.491**	1	
7. PSC-17 Internalizing	-.057	-.137	.039	.193**	.345**	.313**	1

PREDICTORS OF ATTRITION

Exactly one-third of patients dropped from the program prior to attending three visits, and almost half (48%) dropped prior to attending four visits. Using binary logistic regression, attrition status (Retained = 0, Dropped = 1) at the third and fourth visits were regressed on BMI *z*-score at intake, as well as demographic (age, race, gender, insurance status, and parent's preferred language) and mental health (psychiatric medications at intake, and PSC-17 subscales) variables. Listwise N for each model was 176, with 37 cases (17%) deleted from the model due to missing data in at least one variable.

The third visit regression model was not statistically significant (χ^2 (12) = 6.958, p = .860). The overall model explained about 5% (Nagelkerke R^2) of the total variance in patient attrition before the third visit. The model correctly classified about 62% of cases. Of the 12 variables entered into the model, none were statistically significant predictors of attrition before the third visit.

The fourth visit regression model was not statistically significant (χ^2 (12) = 19.899, p = .069). The overall model explained 14.3% (Nagelkerke R^2) of the total variance in patient attrition before the fourth visit. With nonsignificant variables removed, the model was statistically significant (χ^2 (3) = 13.315, p = .004), and explained

9% (Nagelkerke R^2) of the total variance in patient attrition before the fourth visit. The model correctly classified about 68% of cases. Of the 12 variables entered into the model, three were statistically significant predictors of attrition. Parent's preferred language was a statistically significant predictor of dropout in this model (Odds Ratio = .386, P = .017). When compared to youth whose parents who preferred English, youth whose parents preferred Spanish or both Spanish and English were less likely to drop out of the program. These youth had 61.4% (100-38.6) lower odds of dropping out prior to the fourth visit, controlling for other variables in the model. Whether a patient was taking psychiatric medication at intake was also a statistically significant predictor of dropout in this model (Odds Ratio = .295, P = .016). When compared to patients who were not taking psychiatric medication, patients who were taking them showed a 70.5% (100-29.5) reduction in odds of dropping out of the program before the fourth visit, controlling for other variables in the model. Finally, parent-reported inattention on the PSC-17 was also a significant predictor of dropout in this model (Odds Ratio = 1.197, P = .037). A patient's odds of dropping out by the fourth session increased by almost 20% for each one-point increase in PSC-17 Attention subscale score. Logistic regression coefficients for attrition models are displayed in Table 5 below.

Table 5: Attrition Model Regression Coefficients.

Variable	3rd Visit Attrition Model			4th Visit Attrition Model		
	B	*Exp(B)*	*p*	*B*	*Exp(B)*	*p*
Visit 1 BMI *z*-Score	.109	1.115	.826	.096	1.101	.848
Age in Years	.023	1.023	.692	.005	1.005	.937
Female Gender	-.226	.798	.516	.034	1.034	.922
Subsidized/No Insurance	-.171	.843	.676	-.460	.631	.263
Black/African American	.305	1.356	.635	-.530	.589	.401
Hispanic/Latino	.619	1.857	.174	.121	1.129	.784
Other Race	.595	1.812	.340	.284	1.328	.651
Spanish or Bilingual Preference	-.653	.520	.108	-.952	.386	.017
Psych Med at Intake	-.400	.670	.420	-1.221	.295	.016
PSC-17 Attention	.076	1.079	.363	.180	1.197	.037
PSC-17 Externalizing	.018	1.018	.783	-.040	.961	.548
PSC-17 Internalizing	-.053	.948	.517	-.098	.907	.237

PREDICTORS OF BMI CHANGE

Youth patients who attended at least three, four, or five visits showed an average increase in raw BMI of .486 at their last included visit. This difference was statistically significant in a paired-samples t-test ($t(162) = -3.868$, $p < .001$). However, the same sample showed an average decrease in BMI *z*-score of -.027 at their last included visit. This was also statistically significant in a paired-samples *t*-test ($t(159) = 2.020$, $P = .045$).

Using multiple linear regression, BMI *z*-score change was regressed on demographic and mental health variables. The overall regression was not statistically significant ($F(14, 119) = 1.202$, $p = .283$), and accounted for only about two percent (Adjusted *R* Square) of the total variance in BMI *z*-score change. With nonsignificant variables removed, the overall regression was statistically significant ($F(1, 159) = 7.567$, $p = .007$), and accounted for 3.9% (Adjusted *R* Square) of the total variance in BMI *z*-score change. Of the 14 variables entered into the model, average time between visits was the only statistically significant predictor of BMI *z*-score change at the final visit ($\beta = .254$, $b = .002$, $p = .006$). Controlling for other variables in the model, each additional day of average time between visits was associated with a .002 increase in BMI *z*-score change

(.014 increase for each additional week), suggesting that longer intervals between visits predicted poorer weight change outcomes.

Raw BMI change was also regressed on the same independent variables in a multiple linear regression model. The overall regression was statistically significant ($F(14, 119) = 2.236$, $P = .010$), and accounted for 11.5% (Adjusted *R* Square) of the total variance in BMI change. With nonsignificant variables removed, the overall regression was statistically significant ($F(2, 161) = 12.138$, $P < .001$), and accounted for 12% (Adjusted *R* Square) of the total variance in BMI change. Of the 14 variables entered into the model, two were statistically significant. Last visit number (coded '3', '4', or '5'), was a statistically significant predictor of BMI change ($\beta = .181$, $b = .331$, $P = .044$). Each additional visit was associated with a .331 increase in BMI change score, suggesting that, when controlling for other variables in the model, patients whose final visit in the study period was their third tended to do better than those whose final visit was their fourth, and patients whose final visit was their fourth tended to do better than those whose final visit was their fifth.

Average time between visits was also a statistically significant predictor of BMI change ($\beta = .371$, $b = .023$, $P < .001$). Controlling for other variables in the model, each additional day added to the average time between visits was associated with a .023 increase in BMI change (.161 increase for each additional week), again suggesting that longer intervals between visits predicted poorer weight change outcomes. BMI and BMI *z*-score change regression coefficients are displayed in Table 6 below.

Table 6: BMI and BMI *z*-Score Change Regression Coefficients

Variable	BMI Regression Model			BMI *z*-Score Regression Model		
	b	*β*	*p*	*b*	*β*	*p*
Last Visit Number	.331	.181	.044	-.014	-.075	.424
Average Time Between Visits	.023	.371	< .001	.002	.254	.006
Age in Years	.007	.013	.882	.009	.151	.097
Female Gender	.545	.170	.065	.038	.114	.236
Subsidized or No Insurance	-.543	-.157	.105	-.025	-.070	.492
Black/African American	.250	.047	.636	-.006	-.010	.922
Hispanic/Latino	-.163	-.051	.653	-.022	-.064	.590
Other Race	.685	.147	.142	.021	.043	.683
Spanish or Bilingual Preference	.219	.067	.502	.005	.015	.883
Counseling by Last Visit	-.223	-.060	.505	-.014	-.036	.705
Psych Med at Intake	.058	.013	.887	.032	.069	.481
PSC-17 Attention	.021	.033	.768	-.003	-.038	.746
PSC-17 Externalizing	.061	.112	.255	.011	.193	.064
PSC-17 Internalizing	-.031	-.050	.619	.000	-.002	.984

Chapter 4: Discussion

Addressing the problem of child and adolescent obesity, which threatens the current and future health of the United States, has proved to be an enormous challenge. There are many potentially valuable responses to this challenge, including changing national, state, and local policy, improving the model of care at the primary care level, and implementing targeted obesity prevention and intervention programs. Hospital-based multidisciplinary interventions have a key role to play in this array of mitigating approaches; however, success in such programs is often hard won. This study sought to advance understanding of variables that predict clinical change (BMI or BMI *z*-score) as well as attrition from treatment, in order to inform clinical practice with this population.

ATTRITION

Results of this study support findings from previous research; attrition is a challenge for hospital-based multidisciplinary pediatric weight management programs. One-third of patients who attended a first visit in this study dropped out before attending their third session, while nearly half dropped out before their fourth visit. The overall attrition rates observed in this sample were generally consistent with findings from previous studies (Dhaliwal et al., 2014; Skelton et al., 2011), although ways of measuring attrition vary across studies. None of the included variables predicted dropout before the third visit, though several variables predicted dropout before the fourth visit. Youth whose parents preferred Spanish or had no preference between Spanish and English, youth who were taking psychiatric medication at intake, and youth with fewer symptoms of inattention were all less likely to drop out of the intervention prior to the fourth visit. None of the continuous variables in the study (i.e., first visit BMI *z*-score, age, or PSC-17 subscales) were associated with attrition in bivariate correlations.

The overall finding that there were significant predictors of attrition by the fourth visit, but not the third visit, suggests that relevant predictors of attrition from pediatric weight management programs may change as patients progress further into treatment, and what variables predict attrition may depend on how attrition is defined. For example, it may be that common logistical concerns cited by patients in prior qualitative research (Barlow & Ohlemeyer, 2006; Sarah Hampl et al., 2013) predict earlier dropout, while more individual variables, such as symptoms of inattention or caregiver language preference, predict dropout later in treatment. Although past research has defined attrition in various ways, this appears to be the first study to compare multiple dropout cutoffs in the same intervention. Future research should include careful consideration of how attrition is measured, with the understanding that contributors or predictors of attrition may change depending on the chosen cutoff point.

It is notable that, controlling for other variables, parents who preferred Spanish or both Spanish and English had statistically significantly lower odds of dropping out by the fourth visit than those who preferred English only. Spanish-speaking families are likely accustomed to having difficulty accessing care (Avila & Bramlett, 2013), and they tend to be less satisfied with the interpersonal aspects of communication with medical providers when interpreters are needed, especially when ad hoc interpreters are used (Baker, Hayes, & Fortier, 1998). Thus, the families in the present study may have shown high levels of engagement due to the availability of bilingual providers and highly skilled interpreters. While preferred language is certainly not a direct measure of acculturation, this finding also might support the idea that increased acculturation among Hispanic or Latino patients may contribute to poorer engagement in pediatric weight management interventions, which is consistent with some evidence among adults that increased acculturation is a risk factor for obesity in general (Pérez-Escamilla & Putnik, 2007).

Although racial/ethnic group was controlled for in this study, language preference and race/ethnicity are somewhat confounded, and future research should look more specifically at patients who identify as Hispanic or Latino in order to further investigate the ways in which language preference and acculturation might affect attrition. Finally, in this intervention, Spanish-speaking families were likely preferentially assigned to bilingual providers whenever possible. Therefore, it could also be that provider-level variables contributed to the finding that Spanish-speaking families were less likely to drop out of treatment. This is another potentially valuable topic of future research, as identifying provider characteristics that improve treatment retention could lead to positive changes in hiring or staff training practices. This seems to be the first study indicating that language preference may be associated with attrition in pediatric weight management, and more research will be helpful in identifying what is driving this association.

Another potentially surprising finding of this study was that racial or ethnic background was not significantly predictive of attrition. This is contrary to previous research indicating that Black or African American identified youth may be more likely to drop out of treatment prematurely (Tershakovec & Kuppler, 2003; Zeller et al., 2004). It may be that the present intervention was successful in its efforts to retain minority youth, thereby reducing differences in attrition by race or ethnicity. However, it is also possible that the relatively small number of Black or African American identified youth in this sample may not provide an adequate representation of the experience of the overall population. Still, the finding that there were not attrition disparities among ethnic or racial groups in this sample is promising.

Taking psychiatric medications was also associated with lower odds of dropout by the fourth visit. This finding may seem counterintuitive, as one may assume that taking

psychiatric medications is an indicator of poorer mental health. However, one advantage of the logistic regression methods used in this study is that model estimates controlled for overall mental health, as measured by the PSC-17, when examining other variables. When controlling for any negative effects of mental health on attrition, it was observed that taking psychiatric medication is associated with reduced odds of dropout. Prior research has demonstrated that, among youth with ADHD, taking psychiatric medication is associated with slower BMI growth in childhood (Schwartz et al., 2014). It could be that slowed BMI growth caused by ADHD medication also causes patients to feel more successful in treatment, thereby improving retention. This study, however, did not capture the type of medication that was being taken by each patient, so ADHD medications cannot be pointed to specifically in this instance. Still, a clear implication of the present study's finding is that ensuring that patients have access to appropriate psychiatric care may help to prevent youth struggling with mental health difficulties from leaving treatment early. Providing referrals for psychiatry or facilitating psychiatry consults as needed in pediatric weight management clinics could be a way of reducing attrition.

Higher scores on the inattention subscale of the PSC-17 were also found to be predictive of dropout by the fourth visit, with more inattentive symptoms associated with increased odds of early dropout. This is a potentially important finding, as the rate of ADHD among youth with obesity or overweight appears to be higher than in the general population of youth (Erhart et al., 2012). Previous research examining mental health predictors of attrition from pediatric weight management has not identified inattention as a predictor of dropout, though depressive symptoms have been implicated (Zeller et al., 2004). Other studies have found no links between mental health and attrition (Faus & Leibowitz, 2015; Skelton et al., 2011). Interestingly, the Internalizing score subscale of

the PSC-17 was not significantly predictive of dropout in this sample, failing to replicate the finding by Zeller and colleagues (2004). Cortese et al. (2008) suggested that, for individuals with obesity, inattention may be a barrier to adhering to regular patterns of eating and making gains in treatment. Potentially, this lack of adherence to stricter guidelines for diet and exercise could lead to poorer perceptions of treatment effectiveness, and thus more attrition. Of course, this hypothesis linking inattention to attrition remains speculative for the time being, and inattention was not found to be predictive of BMI or BMI *z*-score change, so additional research replicating and exploring the reasons for this link are warranted.

From a practical standpoint, programs may wish to monitor youth with ADHD, or those who are rated by their caregivers as inattentive, as these youth may be at higher risk of attrition from pediatric weight management. What to do once youth at risk for dropout are identified remains unclear, though many patients who leave treatment may be willing to return, given the right circumstances (Kitscha, Brunet, Farmer, & Mager, 2009). Some researchers have used text message reminders (de Niet et al., 2012) or program orientation sessions (Germann, Kirschenbaum, & Rich, 2006) to enhance engagement and reduce attrition. These interventions do seem to be effective at reducing attrition, and could be targeted toward individuals identified as high risk, or used with all patients to ensure that as many as possible are retained.

BMI AND BMI *z*-SCORE CHANGE

Overall, youth in this study showed an average increase in unstandardized BMI from first to last visit of .486, but BMI *z*-scores decreased by an average of .027 in the same period. This finding seems to suggest that taking age and sex norms into account remains important for gauging progress in pediatric weight management. Several studies

have found that BMI *z*-score reductions of .25 to .5 are associated with clinically significant improvement in health indicators (Ford, Hunt, Cooper, & Shield, 2010; Hunt, Ford, Sabin, Crowne, & Shield, 2007; Kalavainen, Utriainen, Vanninen, Korppi, & Nuutinen, 2011; Reinehr & Andler, 2004). For reference, for a ten-year-old, 55-inch-tall boy weighing 96 pounds (approximately 95th percentile for BMI), a loss of one pound represents about a 0.04 reduction in BMI *z*-score, while a loss of five pounds represents a 0.21 decrease in BMI *z*-score. For a 16-year-old, 65-inch-tall female weighing 172 pounds (approximately 95th percentile for BMI), a loss of one pound represents about a 0.02 reduction in BMI *z*-score, while a loss of five pounds represents a 0.1 reduction in BMI *z*-score. While average BMI *z*-score change in this study did not reach .25 in this study, the length of treatment was quite variable, so an average reduction in BMI *z*-score represents a positive result. Cole et al. (2005) found that unstandardized BMI is more sensitive to change over short periods of time for youth when compared to BMI *z*-score, making unstandardized BMI a desirable way of measuring change in many instances. Still, it may be that the variable length of treatment in the present intervention precludes using unstandardized BMI, as some individuals may age enough over the course of the intervention to make unstandardized BMI scores an invalid metric of change. Further, change BMI *z*-score has been found to be more reflective of actual adiposity change in youth when compared to unstandardized BMI change or weight change (Hunt et al., 2007).

The overall BMI *z*-score regression model did not account for a statistically significant proportion of variance in BMI *z*-score change. Average time between visits was the only significant predictor of BMI *z*-score change in this sample. Perhaps none of the other variables included in this study are related to BMI *z*-score change, suggesting that individual patient characteristics are generally unrelated to this particular outcome.

Alternatively, the lack of observed associations between study variables and BMI *z*-score change could also be due to this metric's insensitivity to change among youth with obesity, as documented in prior research (Cole et al., 2005). Still, it is notable that longer intervals between visits did predict poorer BMI *z*-score outcome for patients in the program. Average time between visits was also significantly associated with BMI *z*-score change in bivariate correlations, indicating that the association between these two variables exists regardless of whether or not other variables are controlled for in the model. Standard intervals between follow-up visits in this intervention were already long, at one to two months between clinic visits, and some patients had much longer intervals. It stands to reason that even more infrequent contact with the clinic would not be conducive to positive outcomes, as patients may forget what they learned or lose track of goals between visits. Still, this finding provides evidence that shorter intervals between sessions may be a desirable feature in pediatric weight management programs, and adds to prior literature suggesting that at least moderate intensity of treatment is more effective (Oude Luttikhuis et al., 2009).

Unlike the BMI *z*-score regression model, the unstandardized BMI regression model did account for a statistically significant proportion of variance in BMI change. The only significant predictors of unstandardized BMI change were last visit number and average time between visits, supporting the finding that longer intervals between sessions are associated with poorer outcomes. Both of these associations were also significant in bivariate correlations. Controlling for other variables, patients whose final visit in the study period was their third tended to have better raw BMI outcomes than those whose final visit was their fourth, and patients whose final visit was their fourth tended to have better outcomes than those whose final visit was their fifth. It is likely that this result is due to the effects of normal development, as youths' BMI scores naturally increase as

they age. Another plausible explanation might be that, prior to the fifth visit, patients experience initially high motivation and treatment adherence, followed by a return to old behaviors, though if this were the case, one would expect the same variable to be predictive of BMI *z*-score change as well.

As in the attrition models, racial or ethnic background was not found to be a significant predictor of BMI or BMI *z*-score change in this study, suggesting that there are not disparities across racial or ethnic groups when it comes to achieving results in pediatric weight management. This is promising, given that Black and Hispanic youth have been shown to be disproportionately affected by obesity (Ogden et al., 2014). This finding is also consistent with prior research finding no differences in treatment effectiveness across ethnic or racial groups (Skelton, DeMattia, & Flores, 2008), though more research is still recommended in order to determine the generalizability of this finding. Similarly, the mental health variables included in this study did not predict BMI or BMI *z*-score change. This is similar to findings in previous literature that, although disordered eating behavior may predict weight loss, mental health in general does not appear to do so (Braet, 2006). Overall, this study found few predictors of BMI and BMI *z*-score change, indicating that the variables included do not account for observed variability in these outcomes.

LIMITATIONS

This study has some significant limitations. First, although sample size in this study was similar to other studies of attrition in pediatric weight management (Dhaliwal et al., 2014), sample size could be considered low relative to the number of variables included in the regression models. This limitation may have contributed to type two error, resulting in null results that do not accurately represent the associations between study

variables in the population. Further, describing those who have attended three or four visits as having been successfully retained in the treatment program may be an overly generous threshold, thereby obscuring findings. Further, problems with metrics of adiposity in youth (i.e., BMI and BMI *z*-score) present significant challenges in assessing obesity intervention effectiveness. Unstandardized BMI seems to be the best metric of short-term adiposity change in youth with obesity (Cole et al., 2005), but normal physiological development is likely to invalidate this metric over long treatment intervals. BMI *z*-score may be more valid when examining long-term outcomes, but because of its reduced sensitivity to change among youth with obesity, it may falsely contribute to insignificant findings (Cole et al., 2005). Finally, although the simplicity and availability of the mental health variables used in the study represent strengths when it comes to the overall applicability of study findings to everyday practice, these variables are limited in their depth and scope. A more broad or in-depth examination of mental health variables could provide further insights into the predictive value of mental health in explaining attrition and BMI or BMI *z*-score change in pediatric weight management.

FUTURE RESEARCH

Addressing the problem of child and adolescent obesity in the United States will require continued efforts to develop new interventions and enhance existing ones. Future research in this area should continue to focus on improving interventions for youth with obesity. For instance, given the fact that child and adolescent obesity disproportionately affects some minority groups, research should focus on diverse samples. Further, this research should include not only race and ethnicity, but also more proximal variables such as acculturation, experiences of discrimination, and access to resources. Including these variables will provide a deeper understanding of why these disparities exist,

whether disparities in obesity rates translate to differential treatment outcomes, and how ongoing disparities could be addressed.

While this study examined predictors of BMI *z*-score change in general, further research could also investigate predictors of clinically significant BMI *z*-score change (i.e., change great enough to result in significant health improvement), as defined by previous literature. For example, methods similar to those used in this study could also be applied to predicting which patients achieve clinically significant outcomes versus those who do not. Findings from such research could provide insights applicable to the specific goal of achieving outcomes that are not only positive, but are also clinically significant.

Attrition remains a challenge for pediatric weight management programs. More research is needed in order to understand predictors of attrition and retention, such as mental health and demographic characteristics, so that clinicians can maximize program reach. This study found differences in predictors of attrition at the third and fourth visit. Qualitative and more detailed quantitative methods could be employed to gain additional insights into how reasons for leaving treatment might change depending on phase of treatment.

Finally, the associations between mental health and pediatric obesity are complex, and not well understood. Mental health can be defined and measured in various ways, and future studies should reflect this variety. Continued investigation into the links between mental health and treatment outcomes in pediatric weight management is also needed, as understanding these links and applying this understanding to practice may improve outcomes and allow practitioners to better address children's physical and psychological health needs.

Appendix A: Literature Review

PEDIATRIC OBESITY: DEFINITIONS AND CONCEPTS

Body Mass Index (BMI) and the Definition of Obesity

Body mass index (BMI) is the most widely used determinant of weight status in both adults and children. In the simplest terms, BMI is a measure of body weight adjusted for height. BMI is routinely used in medical settings as a metric of degree of overweight or obesity. More precisely, the purpose of calculating BMI in medical settings is to approximate the adiposity, or body fat, of individuals. For adults, raw BMI scores are used. However, in children and adolescents, BMI percentiles relative to age and sex are calculated as a means of comparing an individual's BMI to other comparable individuals (Krebs et al., 2007). A young person's weight is considered to be in the overweight range if they have a BMI between the 85th and 95th percentile for age and sex, or in the obese range if they have a BMI at the 95th percentile or higher, with norms based on a reference group from the 1970s through the 1990s (Barlow & The Expert Committee, 2007). Although not an official category, some experts also recommend that clinicians recognize an additional severe category of childhood obesity, which includes children at or above the 99th percentile, as these children seem to be at particularly extreme risk for cardiovascular problems (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007).

Raw BMI scores are calculated as a ratio of weight to height, commonly weight in kilograms divided by height in meters squared. Compared to simply measuring weight, BMI is superior in that it accounts for variation in height among individuals. Controlling for height represents a strength of raw BMI scores as a way of determining obesity status. Other methods of measuring adiposity, such as waist circumference, triceps skin fold thickness, dual-energy x-ray absorptiometry (DEXA), impedance-based measures, or

densitometry, are valuable measures, and are often more accurate than BMI (Freedman & Sherry, 2009; Rothman, 2008). However, BMI is still the recommended measurement method for determining obesity status, as these other methods tend to be clinically impractical, and normative data are readily available for comparing an individual's BMI score with representative samples (Barlow & The Expert Committee, 2007).

For children and adolescents, developmental factors add significant complexity when it comes to interpreting BMI scores and determining obesity status. This is because as children age, the composition of their bodies (i.e., percent body fat) varies as a result of normal developmental processes. As an illustration of how development complicates the interpretation of BMI scores, data from the Centers for Disease Control and Prevention show that a BMI of 23 is approximately at the 50th percentile for a 20-year-old man, but is at about the 97th percentile for a 10-year-old boy (Kuczmarski et al., 2002). For this reason, BMI in youth is almost always converted to a percentile or z-score based on age and sex norms (reported periodically by the Centers for Disease Control and Prevention) prior to interpretation. BMI adjusted for sex and age has been shown to have high specificity, sensitivity, and predictive value for health risk factors, indicating that it is a clinically valid way of estimating body composition in youth (Freedman & Sherry, 2009).

Despite its clinical utility, BMI as a measure of obesity/adiposity has several limitations. First, as discussed above, BMI is an indirect, and potentially inaccurate, measure of adiposity. This seems to be a problem when using BMI to assess adiposity in children who are closer to the middle of the BMI distribution (i.e., children in the normal weight range), as BMI differences can be due to differences in fat-free mass (Freedman & Sherry, 2009). Second, standardized BMI scores (i.e., BMI z-score or BMI percentile), although essential in assessing adiposity in children and adolescents, can have reduced

variability among children at the high end of the distribution (i.e., children with obesity or underweight children), and therefore reduced sensitivity to change (Cole et al., 2005).

Despite some limitations, the standardized BMI score (i.e., BMI *z*-score or BMI percentile) is the most widely accepted and understood metric of obesity in children and adolescents, and it allows clinicians to quickly and easily identify youth who are at risk for comorbidities and later health problems associated with overweight and obesity. When compared to weight loss or unstandardized BMI reduction, BMI *z*-score reduction is also more reflective of actual fat loss in youth (Hunt et al., 2007). In sum, BMI is a clinically valid measure of adiposity that accounts for normal developmental variations in body composition, and it can be easily and reliably measured using widely available medical equipment (Freedman & Sherry, 2009).

Overall Prevalence of Obesity in Youth

Recent data from the National Health and Nutrition Examination Survey (NHANES) clearly show that rates of child and adolescent obesity have increased greatly since the 1960s and 1970s, and have reached alarming levels. About 17% of children and adolescents in the United States now have BMI in the obese range, up from approximately 5% in the early 1970s (Ogden et al., 2014). Although it is more pronounced in the United States, this trend appears to be worldwide (Ebbeling et al., 2002). Fortunately, data indicate that the rate of increase has slowed or stopped since approximately 2003 (Han, Lawlor, & Kimm, 2010; Ogden et al., 2014). Obesity rates among American preschoolers also seem to have trended back down between 2003 and 2010 (Pan, Blanck, Sherry, Dalenius, & Grummer-Strawn, 2012). Despite these promising trends, current rates of obesity are still three times as high as the were in the

1960's, and until they are drastically decreased, this problem will remain a pressing public health concern in the United States.

Racial and Ethnic Disparities in Pediatric Obesity

Although obesity in youth is widely considered an issue of national concern in the United States, the problem does not affect all segments of the population equally. The overall rate of obesity among American youth is about 17%, but obesity rates vary drastically across racial/ethnic groups. It has been a challenge for researchers to identify what variables account for the differences in youth obesity rates across American ethnic/racial groups. Economic conditions, environmental inequalities, cultural differences, and racism appear to combine to determine differences in youth obesity rates across group, though the roles of each of these elements are not well understood.

As Table 7 below illustrates, rates of childhood obesity are significantly higher among Black and Hispanic youth than their White and Asian peers (Ogden et al., 2014).

Table 7: Obesity Rates Among 2-19 Year Olds By Ethnic Background.

Race/Ethnicity	Percent With Obesity
All	16.9
White	14.1
Black	20.2
Hispanic	22.4
Asian	8.6

Source: (Ogden et al., 2014).

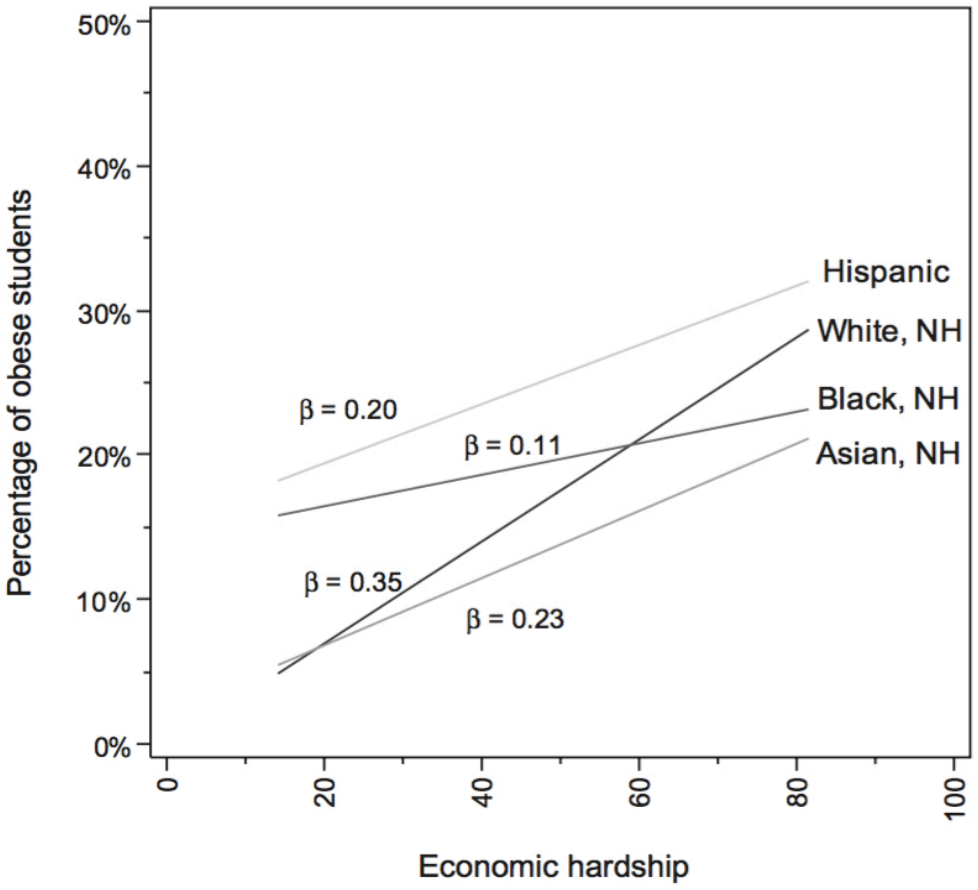
Socioeconomic Variables Impacting Youth Obesity Rates

Socioeconomic status (SES) is highly correlated with ethnic background in the U.S., and many environmental variables related to SES may mediate the relation between race and youth obesity, or may act as confounding variables when studying the relation

between ethnic background and youth obesity (Bacha et al., 2010; Kumanyika, 2008; Singh, Kogan, Van Dyck, & Siahpush, 2008). Thus, it could be assumed that differences in obesity rates across group are simply attributable to economic hardship, and the associated contextual disadvantages. However, research in this area is not conclusive.

Economic and associated environmental variables do seem to correlate with youth obesity rates, but some evidence indicates that the effect of economic hardship on childhood obesity rates varies across racial/ethnic groups. For instance, as shown in Figure 1 below, the effect of economic hardship on childhood obesity rates seems to be stronger for White and Asian youth, and least strong for Black youth (Shih, Dumke, Goran, & Simon, 2013). This difference suggests that certain risk factors exist for minority groups across levels of economic hardship. Further, associations between youth obesity and socioeconomic status seem to vary in unpredictable ways across age, gender, and race, and the association between SES and obesity seems to be weakening over time (Wang & Zhang, 2006). In contrast, more recent findings indicate that in some populations, differences in childhood obesity rates across ethnic groups may be entirely explained by economic hardship (Rogers et al., 2015). Thus, it remains unclear whether differences in obesity rates across racial/ethnic groups might be explained by differences in socioeconomic status, or whether more proximal variables should be considered when examining racial disparities in youth obesity. The following sections summarize findings from the literature surrounding these proximal variables.

Figure 1: Percentage of Youth With Obesity Among 5th to 9th Graders Across Levels of Economic Hardship.



Source: (Shih et al., 2013).

Community Environmental Variables and Youth Obesity Rates

Community environmental variables, including the availability of healthy food and access to places for individuals to engage in physical activity, may help explain differing obesity rates across groups. Poor neighborhoods with predominantly ethnic minority populations are often affected by the "food desert" phenomenon. In such neighborhoods, healthy foods from affordable chain supermarkets are less readily available, while unhealthy foods from fast food restaurants and convenience stores are

ubiquitous (Walker, Keane, & Burke, 2010). Thus, the options for healthy food tend to be more limited for people living in lower-resourced communities. This is one possible contributor to disparities in obesity rates by ethnic background or SES, and food deserts have recently been shown to be associated with higher BMI in elementary school children (Thomsen, Nayga, Alviola, & Rouse, 2016).

Similar to the availability and affordability of healthy food, opportunities for healthy physical activity tend to be limited in lower SES communities. Facilities that are conducive to exercise are simply less abundant in poorer neighborhoods (Moore, Diez Roux, Evenson, McGinn, & Brines, 2008). Schools that serve low SES children also have fewer resources supporting physical activity (Carlson et al., 2013). Compounding these issues is the presence of safety concerns in lower SES neighborhoods, which may prevent children and adolescents from accessing outdoor areas that would otherwise provide opportunities for physical activity (Bacha et al., 2010). Neighborhoods low in environmental resources supporting physical activity and good nutrition (e.g., parks and supermarkets) have higher rates of childhood obesity, further supporting a link between the physical environment and childhood obesity (Saelens et al., 2012).

Racism and Youth Obesity Rates

When it comes to understanding the disparate obesity rates across American racial or ethnic groups, racism is also a likely contributor. Racism is not constrained within the bounds of particular economic groups, and it can therefore affect members of ethnic minority groups regardless of economic prosperity. As an example of how racism can cut across class lines to impact nutrition, one study found that African American families shopping at well-resourced, predominantly White grocery stores reported feeling unwelcome due to racist and discriminatory experiences (Baker et al., 2006). Further,

experiencing racism has shown to be positively associated with health variables such as obesity, hypertension, and heart rate (Brondolo, Love, Pencille, Schoenthaler, & Ogedegbe, 2011; Cozier et al., 2014; Paradies, 2006). There is also evidence that experiencing racial discrimination may reduce healthy eating among ethnic minorities, even among those with beliefs supportive of healthy food intake (Manuel, 2004). These findings linking the experience of racism to health may help to explain the persistence of racial differences in obesity rates independent of SES.

Acculturation and Youth Obesity Rates

Family acculturation may also play a role in determining patterns of obesity across racial/ethnic groups. Among Latino or Hispanic adults, there is strong evidence that increased acculturation is associated with higher rates of obesity (Pérez-Escamilla & Putnik, 2007). For children, findings seem to be less consistent both within and across studies, with some evidence indicating that more acculturation is protective and other evidence suggesting the opposite is true (Chen & Kennedy, 2004; Kaiser et al., 2001; Wojcicki et al., 2012). So, while it is clear that, at least for Latino or Hispanic adults, acculturation appears to increase risk for obesity, less is known about the impact of acculturation on youth obesity rates. Further, heterogeneity within racial and ethnic groups may make it difficult to generalize about the role of acculturation in obesity rates. Additional research is warranted in order to more fully understand the relationship between obesity and acculturation in youth.

Demographics and Youth Obesity: Conclusions

While there are some variables that show promise in helping to explain youth obesity disparities across ethnic groups in the United States, including access to healthy food, access to opportunities for physical activity, experiences of racial discrimination,

and differences in family acculturation, more evidence is needed in order to establish causal links. Recent evidence indicates that socioeconomic status cannot solely be blamed for the disparate rates of obesity across racial/ethnic groups in the United States. The specific variables mediating associations between race and obesity need to be studied more intensively, as African American and Hispanic youth continue to be disproportionally represented among youth with obesity. When it comes to intervention research, many studies use small, homogeneous samples, producing results that may not apply to socioeconomically and ethnically diverse populations. Therefore, it is critical that studies on obesity intervention for youth be inclusive of ethnic minority and low SES populations, and that researchers and clinicians alike take the unique experiences of these populations into account when designing interventions and interpreting research findings.

PEDIATRIC OBESITY: ASSOCIATIONS WITH PHYSICAL AND MENTAL HEALTH

Pediatric Obesity and Physical Health

Although individuals with obesity are often stigmatized in the U.S. based on appearance, concerns about obesity in the medical community are not based on cosmetics, as obesity poses a serious threat to the health of American youth. The adverse health effects of obesity in youth are well documented. Immediate complications include cardiovascular problems, asthma, type 2 diabetes, and many other serious conditions (Deckelbaum & Williams, 2001; Must et al., 1999; Reilly et al., 2003). Type 2 diabetes rates provide a striking example of the immediate impacts on the health and quality of life of children and adolescents. For example, study of adolescents in the Cincinnati area found that type 2 diabetes increased by about 10 fold between 1982 and 1994 in association with a rise in pediatric obesity (Pinhas-Hamiel et al., 1996). More recently, between 2001 and 2009, prevalence of type 2 diabetes in youth age 10 to 19 increased

significantly for White, Hispanic, and Black youth, resulting in an overall 30.5% increase in type 2 diabetes among youth (Dabelea et al., 2014).

Obesity in youth is associated with several medical comorbidities that affect health during childhood and adolescence, but many health consequences emerge much later in life, and result in higher morbidity and functional impairment. For example, if a child or adolescent has obesity, his or her obesity tends to persist into adulthood, and is associated with later type 2 diabetes, hypertension, sleep apnea, orthopedic problems, and premature death (Dietz, 1998; Reilly et al., 2003). There are a number of cardiovascular risk factors that, in adults, predict diabetes onset, atherosclerotic disease, and increased mortality. These risk factors include obesity, elevated triglycerides, elevated blood pressure, and elevated fasting blood glucose. Among adolescents seeking treatment for obesity, about 30% have 3 or more of these risk factors, a combination often referred to as 'metabolic syndrome', and thought to be indicative of serious risk for future cardiovascular health problems (Wickham et al., 2009). Even for children between the ages of five to ten who are overweight, more than 60% are likely to have at least one serious cardiovascular risk factor (Freedman, Dietz, Srinivasan, & Berenson, 1999).

Obesity in youth is a serious public health issue. The costs of treating pediatric obesity have increased, posing a financial burden for families of patients with obesity, and for society as a whole. One alarming projection estimates that, if the current rate of increase persists, obesity and overweight will account for 16-18% of total healthcare costs in the U.S. by 2030 (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008). Research has clearly demonstrated that obesity in youth is associated with concurrent health problems, cardiovascular risk factors, obesity later in life, and a number of health complications in adulthood.

Pediatric Obesity and Mental Health: An Overview

In addition to physical health problems, obesity in youth is associated with increased mental health and social challenges. Much research has examined the links between mental health problems and obesity in youth. Although depression seems to be the psychological problem most strongly linked to obesity, other associations have been documented as well (Munson, 2004; Puder & Munsch, 2010). Although many youth with obesity do not experience clinically significant mental health challenges, a significant proportion do seem to experience these negative effects, highlighting the need for interventions that focus on mental health in addition to physical health.

One of the major sources of mental health and social difficulties for children and adolescents with obesity is the appearance-based stigmatization endured by these individuals in the U.S.. Youth with obesity face weight-based stigmatization from many prominent figures in their lives, including peers, educators, parents, and medical professionals (Gray et al., 2009; Puhl & Latner, 2007; Strauss & Pollack, 2003). This stigma is manifested in the lives of individuals with obesity in the form of mistreatment and negative stereotyping, causing psychological harm and differential treatment (Puhl & Brownell, 2006). Despite movements aimed at reducing stigma, since the 1960s children's perceptions of the likeability of peers with overweight or obesity seem to have gotten worse (Latner & Stunkard, 2003). Thus, it is not surprising that youth with obesity have been found to have significantly lower self-esteem, lower quality of life, increased body dissatisfaction, and more difficulties in interpersonal relationships when compared to peers without obesity, though these associations are sometimes weaker for boys and for those not seeking intervention (Braet et al., 1997; Buttitta, Iliescu, Rousseau, & Guerrien, 2014; French et al., 1995; Merten et al., 2008; Puhl, 2007; Strauss, 2000). Many of the negative effects of obesity on mental health are likely the products of social

rejection, stigmatization by others, and a cultural climate that is unaccepting of larger body size (Cogan, Bhalla, Sefa-Dedeh, & Rothblum, 1996).

Although there are clear associations between mental health and obesity in youth, the causal direction between these variables is not well understood. It is often assumed that having excess weight affects emotional health and social functioning negatively by way of social stigma, but there is also evidence that the relation works in the opposite direction as well. For instance, a prospective cohort study found that adolescent depression at baseline independently predicted obesity at 1 year follow-up, even after controlling for initial body mass index (BMI) and other important baseline variables (Goodman & Whitaker 2007). Hasler et al. (2005) documented a similar relation between childhood depression and obesity in adulthood. A 2008 meta-analysis also found that there is clear evidence that depression predicts later obesity (Blaine, 2008). Thus, it should not be assumed that obesity is necessarily a direct or indirect cause of mental health difficulties, as it also seems to be an outcome of such difficulties.

Looking beyond depression, many studies have demonstrated that both externalizing (e.g., impulsivity) and internalizing (e.g., anxiety and depression) problems predict obesity for children and adolescents (Puder & Munsch, 2010). The effects of psychological variables on obesity are often thought to be mediated by health behaviors, such as decreased physical activity, eating unhealthy foods as a means of coping with distress, or loss of behavioral control. However, there are plausible arguments that biological aspects of mental health conditions may influence weight directly (Puder & Munsch, 2010). For example, cortisol reactivity could mediate the association between depression and BMI (Dockray, Susman, & Dorn, 2009). Thus, biological mechanisms, in addition to behavioral ones, may help to explain how mental health impacts obesity.

The following sections provide an in-depth review of the literature pertaining to how child and adolescent obesity relates to key mental health challenges that youth face, focusing specifically on internalizing problems, as well as externalizing problems and ADHD. Cross-sectional and longitudinal findings are explored. Additionally, causal mechanisms linking mental health problems and youth obesity are explained, applying both theoretical and empirical evidence. Understanding these connections provides a foundation from which to explore how mental health concerns could impact the effectiveness of pediatric weight management programs.

Pediatric Obesity and Internalizing Problems

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM 5), indicates that the grouping of psychological problems into 'internalizing' and 'externalizing' subgroups is a valid and useful way to categorize disorders. Within this framework, internalizing problems involve disorders with "…prominent anxiety, depressive, and somatic symptoms" (American Psychiatric Association, 2013). Much of the research linking obesity and mental health has focused on the association between depression, considered an internalizing disorder, and obesity. Rates of anxiety and mood disorders in the overall population of children and adolescents are estimated at about 0.7% and 3.7% respectively (Merikangas et al., 2010). Depression seems to be quite common among adolescents and adults with obesity, and in recent years, research has contributed some hypotheses about the causal relations between depression and obesity. Further, there is some evidence that gender, and potentially race, may play a moderating role on this connection.

Cross-Sectional Associations

Cross-sectional data has shown mixed results when it comes to demonstrating the concurrent presence of depression and obesity. Indeed, some research indicates that there is no correlation between depression and obesity measured at a single time point (Goodman & Whitaker, 2002). However, other research suggests that there is likely a small, but statistically significant, correlation between depression and obesity (Blaine, 2008; Markowitz et al., 2008). Still other findings support the notion that individuals in the overweight range may fare better in terms of depression than both normal weight and obese peers (Johnston, Johnson, McLeod, & Johnston, 2004). Among children followed from birth to 14 yeas old, there seems to be little association prior to age seven, and a strengthening, albeit small, association as children age (Bradley et al., 2008). Taken together, the literature suggests a small concurrent relation between depression and obesity, but findings also reinforce the notion that individuals with obesity should not be assumed to suffer from mental illness. Further, the association between internalizing problems and obesity seems to emerge first during middle childhood.

Although substantial research has examined the associations between obesity and depression, less is known about the associations between obesity and anxiety, another major category of internalizing problems. In one sample of children seeking hospital-based obesity treatment 32% had a diagnosable anxiety disorder, 12% had a diagnosable depressive disorder, and anxiety symptoms were significantly higher than for youth without obesity seeking treatment for diabetes (Vila et al., 2004). While estimates from treatment-seeking samples may overestimate the prevalence of anxiety problems in the general population of youth with obesity, this finding is still alarming. Several other studies have shown small but significant positive associations between obesity and

anxiety (Gariepy, Nitka, & Schmitz, 2010; Jorm et al., 2003). Thus, similar to depression, anxiety seems to be a common comorbidity of obesity in youth.

Longitudinal Associations

Although cross-sectional data indicates a small association between depression and obesity, findings from prospective studies are more troubling. A large review and meta-analysis, encompassing over 58,000 participants, found that people with obesity at baseline were at a 55% increased risk for depression at follow up, and those who were depressed at baseline were had a 58% increased risk of having obesity at follow up (Luppino et al., 2010). A previous meta-analysis also found that depression at baseline predicted obesity at follow up, especially for adolescent females (Blaine, 2008). These strong findings suggest that depression and obesity are risk factors for one another, hinting at complex underlying mechanisms tying them together. This is also further evidence for a bidirectional relationship between obesity and depression.

Much of the research linking depression and obesity over time has focused on participants who, at least at follow up, were adults. Among adolescents there is some evidence that obesity might not predict depression a year later, but that depression predicts obesity across this time period (Goodman & Whitaker, 2002). Overall, longitudinal data linking obesity and depression are less strong for youth than they are for adults. They suggest that depression may predict later obesity, but that obesity might not predict later depression in young people, as it does in adults. However, more studies are needed in order to draw firm conclusions.

Moderating Variables

Not much is known about variables that might moderate the associations between internalizing problems and obesity, though gender, age, and racial/ethnic background

could play a role. For instance, BMI or obesity status seems to have a stronger association with depression among girls or women (Anderson, Cohen, Naumova, Jacques, & Must, 2007; Blaine, 2008; Erickson, Robinson, Haydel, & Killen, 2000; Hasler et al., 2005; Richardson et al., 2003). Among adolescents, however, a diagnosis of depression was not generally found to be associated with BMI, though having depression did predict obesity specifically among Black and male adolescents (Merikangas, Mendola, Pastor, Reuben, & Cleary, 2012). Age could also have a moderating influence, as the association between internalizing problems and obesity strengthens after about age seven (Bradley et al., 2008). However, a large review of the literature found that, while the association between baseline obesity with later depression was stronger for Americans than Europeans, there were no other significant moderators when predicting depression from baseline obesity or vice versa across 15 studies (Luppino et al., 2010). Overall, the strongest moderator of the association between obesity and internalizing problems seems to be gender, with women and girls showing stronger associations than men and boys, though age may also have an effect.

Similar to depression, for anxiety there seems to be a stronger association with obesity for females than males (P. Anderson & Butcher, 2006; S. Anderson et al., 2007; Jorm et al., 2003). Interestingly, in a predominantly African American and Hispanic sample of urban high school students, anxiety symptoms did not differ by weight status, providing preliminary evidence that race could moderate the association between anxiety and obesity (Pastore, Fisher, & Friedman, 1996). Thus, findings in the literature warrant additional investigation of how race and gender might impact the association between anxiety and obesity.

Causal Associations

Although the causal pathways linking internalizing problems and obesity have not been thoroughly studied, several plausible hypotheses have been discussed in the literature. For instance, Luppino et al. (2010), in their review of the literature, outlined a number of possible causal pathways from obesity to depression, including obesity as a chronic inflammatory state, dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, brain alterations caused by obesity related diabetes, increased pain, and diminished self-perception within a rejecting cultural context. These authors also discussed mechanisms by which depression could lead to obesity, including long-term HPA axis disturbance, interactions between insulin levels and body fat storage, unhealthy changes in lifestyle, and antidepressant use. Similarly, Markowitz et al. (2008) argued that obesity might cause depression by means of obesity-related physical impairment, repeated dieting, poor body image and perceptions of health, as well as social stigma. These authors also implicated reduced treatment adherence, negative cognitions, and lack of social support as ways in which depression may cause obesity.

Each of the proposed causal pathways outlined above shows promise in explaining the links between internalizing problems and obesity, but most remain untested, and the relative importance of each of these pathways is still unclear. Further, none of this research has taken development into account, so it is possible that some causal relations may be present in adults, but not children. For example, problems with body image and social stigma require some level of cultural socialization, identity development, and the capacity for social comparison. Ideally, future research about these causal relations will include individuals across the lifespan.

Conclusions

Overall, studies have shown links between internalizing problems and obesity, especially when these associations are examined over time. There may be a bidirectional relationship between these internalizing challenges and obesity, such that each contributes to the development of the other. In some instances, age and gender may moderate these links, with females, adolescents, and adults showing stronger links. Ethnic background may also be a moderator, with obesity showing weaker associations with internalizing problems among minority youth. Though not thoroughly researched, some plausible biological, psychological, and social causal pathways have been proposed to explain these associations. Unfortunately, much of the research on these topics has been done using adult samples, so developmental trends in these associations are not well accounted for in the literature.

Pediatric Obesity, ADHD, and Externalizing Problems

Externalizing problems, like internalizing problems, represent a cluster of psychological and behavioral challenges. Externalizing problems are generally characterized by "…impulsive, disruptive conduct, and substance use symptoms" (American Psychiatric Association, 2013). There is significant overlap between symptoms of attention-deficit/hyperactivity disorder (ADHD) and externalizing problems. A growing body of research has looked at the links between externalizing problems, ADHD, and obesity. Cross sectional and longitudinal studies have shown mixed results, but they suggest possible links between externalizing problems, ADHD, and obesity. Further research has examined potential moderators and causal mechanisms affecting these associations, though more research is needed in this area. This section provides an overview of research findings on this topic.

Cross-Sectional Associations

Much of the research in this area has focused specifically on ADHD, a very common disorder in childhood and adolescence. A recent nationally representative survey of parent-child dyads found that, while the overall prevalence of ADHD in the population was around 4%, the prevalence among overweight and obese youth was 7%, and children with ADHD were twice as likely to be overweight or obese than were peers without ADHD (Erhart et al., 2012). However, an earlier review of cross-sectional research on the link between ADHD and obesity revealed that children with ADHD tended to have higher than expected BMI, but the evidence for increased prevalence of obesity status among kids with ADHD is less consistent (Cortese et al., 2008). These studies offer generally strong evidence for a link between ADHD and obesity in youth.

Additional cross-sectional research has looked at the associations between conduct problems or overall externalizing problems and obesity in youth. For instance, relative to peers without obesity, youth with chronic obesity have shown a two and a half-fold increased risk for oppositional-defiant disorder (Mustillo et al., 2003). Further, controlling for ADHD comorbidity, children with oppositional-defiant and conduct problems tended to have higher BMI than those without these problems in one study (Pauli-Pott, Neidhard, Heinzel-Gutenbrunner, & Becker, 2014). Finally, when compared to diabetic controls, children and adolescents getting treatment for obesity present with more externalizing symptoms (Vila et al., 2004). Despite these findings, some investigators have found no or small associations between externalizing problems and obesity (Pine et al., 1997; Van Vlierberghe & Braet, 2007). Overall, most literature supports the notion that obesity increases the risk of ADHD or externalizing problems and vice versa, though this finding is not universal.

Longitudinal Associations

Understanding the longitudinal associations between obesity, ADHD, and externalizing problems provides a further step toward understanding how these variables might contribute to one another. When it comes to obesity and ADHD, in a sample of more than 150,000 American youth, ADHD not treated with medication predicted higher BMI, while ADHD treated with stimulant medications predicted slower BMI growth in childhood, but a BMI rebound in adolescence (Schwartz et al., 2014). This is similar to cross-sectional findings, which suggest that treatment with medication may moderate the otherwise positive association between ADHD and obesity in childhood and adolescence (Waring & Lapane, 2008). Thus, ADHD generally seems to predict higher BMI at future time points, albeit with a potentially strong moderating effect of stimulant medication.

Additional longitudinal research has examined other externalizing problems as they relate to obesity in youth. A longitudinal study of Finnish males found that moderate and high levels of conduct problems at eight years old were associated respectively with two- and three-fold increases in the risk of obesity in adulthood (Duarte et al., 2010). Other evidence suggests that, over a 9 to 35 year period, conduct problems in youth are associated with a small increased risk for obesity (Pine et al., 1997; von Stumm et al., 2011). In contrast, one study of 459 female youth found a strong link between conduct disorder at 15 and poorer health at 21, but conduct disorder in this sample was actually associated with reduced BMI (Bardone et al., 1998). Overall, longitudinal research linking externalizing problems with later obesity is mixed, but suggests a small but significant association.

Moderating Variables

As noted in the previous section, when studies looking at the longitudinal relations between ADHD and obesity in youth included medication in their analyses, they

found that taking medication may reduce the effect of ADHD on the development of obesity (Schwartz et al., 2014; Waring & Lapane, 2008). Another noteworthy finding came from an investigation examining externalizing behavior rated at two-years-old as it related to BMI between the ages of two and 12. Externalizing behavior at two-years-old predicted higher BMI across the age span, but while the BMI disparity between externalizing and non-externalizing children remained stable across time for White children, this disparity became more pronounced over time for their minority peers (S. Anderson et al., 2010). This indicates that the affects of early externalizing problems on BMI may be more severe for minority youth. Overall, there is some limited evidence that the relation between externalizing problems and obesity may be moderated in some cases by medication, gender, and potentially race.

Causal Associations

Several plausible causal mechanisms have been posited to explain observed links between ADHD or Externalizing problems and obesity. Genetics is one possible explanation for these associations. A study looking at shared genetic risk factors between ADHD and obesity in youth found that, out of 32 known genetic obesity risk factors, only two alleles were also associated with ADHD, and the associations were weak and directionally inconsistent (Albayrak et al., 2013), so at this time a genetic link between ADHD and obesity has not been substantiated in the literature. Although it is logical to suppose that impulsive eating may connect ADHD to obesity, it also makes sense that hyperactivity could lead to greater energy expenditure, acting as a protective factor against obesity, though evidence does not generally support this hypothesis (Holtkamp et al., 2004). A more promising causal model indicates that a combination of strongly reward-driven eating and reduced inhibitory control may drive an interaction between

reward sensitivity, impulsivity, and obesity (Appelhans, 2009). Additional research implies an underactive dopamine reward system as a shared causal influence on ADHD and obesity. This "reward deficiency" hypothesis is supported by findings that low brain dopamine levels predict overeating and obesity, and that artificially increasing dopamine levels results in reduced feeding behavior (Liu et al., 2008). It is less understood how inattention, a hallmark symptom of ADHD, could be linked to obesity, though some have speculated that inattention and deficits in executive functioning may lead to more difficulty adhering to regular eating patterns and attending to hunger cues (Cortese et al., 2008). Although far from conclusive, there are plausible arguments for causal links between obesity, ADHD, and externalizing problems.

Conclusions

A number of studies have demonstrated links between externalizing problems, ADHD, and obesity in youth. Though not uniformly strong, research suggests that ADHD and externalizing problems are associated with an increased risk of concurrent or later obesity. However, there is some evidence for moderating effects of gender, ethnic background, and medication use, though more research is needed. Finally, a number of causal mechanisms to explain these associations have been circulated. Genetic links do not seem to explain the link for ADHD, but findings do seem to implicate brain-based reward mechanisms as a promising mediator between ADHD and obesity.

INTERVENTIONS TARGETING PEDIATRIC OBESITY

Theoretical Considerations and The Structure of Interventions

Since the 1990s, the field of pediatrics has made concerted efforts to develop recommendations for addressing the problem of pediatric obesity in medical settings. These recommendations are not grounded in an explicit theoretical framework, though

some theoretical assumptions can be inferred from official recommendations for care. Although there are official recommendations regarding the structure and components of pediatric weight management programs, there remains no gold standard intervention to address obesity in youth. The most authoritative systematic review on interventions for obesity in youth concludes that "…family-based, lifestyle interventions with a behavioural [sic] program aimed at changing diet and physical activity patterns provide significant and clinically meaningful decrease in overweight in both children and adolescents compared to standard care or self-help in the short- and the long-term" (Oude Luttikhuis et al., 2009). Similarly, based on the most current evidence for the effectiveness of obesity interventions for youth, the U.S. Preventative Services Task Force offered a "grade B" recommendation, indicating high confidence in "moderate to substantial benefit", that children over 6 be screened for overweight and provided behavioral intervention as needed (US Preventive Services Task Force, 2010). These guidelines for the treatment of pediatric obesity, though quite broad, are being acted upon in various contexts to combat pediatric obesity.

In 1997, the Maternal and Child Health Bureau, Health Resources and Services Administration, and the Department of Health and Human Services collaborated to assemble an expert committee to provide practice recommendations for clinicians based on the latest scientific evidence and clinical experience in the field of pediatric obesity. In a seminal 1998 document, recommendations from this committee were presented to guide the evaluation and treatment of pediatric obesity in medical settings (Barlow & Dietz, 1998). In 2007, an expert committee was again convened in order to revise and update these recommendations (Barlow & The Expert Committee, 2007). These recommendations represent a model for best practice for the medical treatment of obesity in youth, and they comprise a foundation upon which evidence-based pediatric obesity

interventions can be built. The recommendations from the expert committee remain highly influential. Children's hospitals in particular have responded to the literature by establishing 'Stage 3' intervention programs, which employ intensive structured multidisciplinary interventions in hospital settings (Children's Hospital Association, 2014).

The expert committee recommendations are expansive, with suggestions ranging from preventative strategies for children in the normal weight category, to treatment recommendations for youth with severe obesity, devastating medical comorbidities, and who have not responded to serious efforts to reduce their obesity. The recommendations also reach across varied contexts and systemic levels, ranging from individual behavior change to reforms at the federal level. Regarding stage 3 interventions, the expert committee suggests a number of features of these programs, including a multidisciplinary team approach, structured behavior modification related to diet and physical activity, active parent participation, systematic evaluations, and frequent visits (Barlow & The Expert Committee, 2007). The breadth of the expert committee recommendations is a reflection of the understanding that the causes of childhood and adolescent obesity are myriad, and that a serious attempt to address this issue must attend to all contributing variables, and must act across multiple contexts.

Although not explicitly stated, the recommendations outlined above for reducing obesity in youth seem to be consistent with a biopsychosocial model of disease (Engel, 1977). The biopsychosocial model was proposed by the American psychiatrist George Engel as a challenge to the dominant biomedical model, which Engel viewed as reductionistic and dualistic, reinforcing a socially constructed separation between mind and body. Borrowing from the broader systems theory made popular in the field of biology, the biopsychosocial model incorporates biological, psychological, social, and

cultural variables in its conceptualization of the etiology and presentation of disease. In practice, this theoretical orientation leads to treatment strategies that incorporate psychological, biomedical, and social/contextual interventions in order to treat what might otherwise be viewed as intra-individual, biologically-based medical problems. Thus, recommendations from the Expert Committee that interventions attend to multiple systemic levels, contexts, and disciplines seem to be informed by the biopsychosocial model (Barlow & The Expert Committee, 2007).

One finding that has theoretical implications is the discovery that, unlike adults, children who participate in weight management programs seem to have better long-term outcomes than controls ten years post-treatment (Epstein, Valoski, Wing, & McCurley, 1994). Certain aspects inherent to childhood may make children more likely to be successful in pediatric weight management. Outlining some possible explanations for the better long-term outcomes of children versus adults, one author hypothesized that children may be easier to teach, that biological mechanisms may favor early intervention, and that children can rely on parents to change their environment rather than needing to exercise strict self-control (Wilson, 1994). The latter assertion is supported by the finding that family-based interventions seem to be more effective for treating obesity in youth than individually based ones (Oude Luttikhuis et al., 2009). It is also reasonable that variables such as these could explain why children can experience more long-term positive effects of treatment. It also provides a good rationale supporting early intervention and prevention efforts.

BMI Change in Pediatric Weight Management

Although serious efforts have been made to address the problem of child and adolescent obesity, clinically significant BMI change is difficult to accomplish, and even

more challenging to sustain. Pediatric weight management programs, no matter how well implemented, are pushing against powerful societal forces that contribute to the problem of obesity. Further, the short-term effectiveness of restrictive diet programs may divert attention from programs focused on long-term lifestyle change. Still, research reveals that, despite these challenges, multidisciplinary weight management programs for children and adolescents can be effective.

Several literature reviews and meta-analyses have attempted to summarize the research on outcomes in pediatric weight management in order to guide future research and offer suggestions for clinicians. Meta-analyses of intervention studies targeting weight reduction in children and adolescents have found that behavioral lifestyle, and structured interventions tend to result in modest reductions in weight (Oude Luttikhuis et al., 2009; Snethen et al., 2006). Unfortunately, these studies were not able to identify specific features making some interventions more effective than others. Literature reviews on this topic have come to similar conclusions, reporting that while patients are often able to reduce BMI and experience lasting change, there is little indication that one specific type of program is superior to another (Epstein, Myers, Raynor, & Saelens, 1998; Jelalian & Saelens, 1999). In an attempt to translate research findings into more concrete practice recommendations, scholars suggested careful planning and resource allocation in the construction of programs, and endorsed a combined medical and psychological approach (Edwards & Schwarzenberg, 2009).

Although it is well established that treatment effects can be achieved, especially in programs involving structured caloric restriction, maintenance of weight loss remains a challenge (J. Anderson, Konz, Frederich, & Wood, 2001). Therefore, it is important to determine whether long-term maintenance is achieved in pediatric weight management. In a study of the Bright Bodies weight management program, it was found that, compared

to baseline, BMI *z*-scores remained significantly reduced one year after treatment (Savoye et al., 2005). Further, there is evidence that the benefits of intervention can be sustained far into the future. In a study of 158 families who received intervention for 6-12-year-old children with obesity, about 30% had BMI below the obese range after 10 years, and about one third reduced their weight at least to 20% overweight (Epstein et al., 1994). However, a limitation of this study was the lack of control group. So, while research findings seem to suggest that obesity treatment for youth can have long-term benefits, more research is needed in this area.

Another gap in the research exists when it comes to how well interventions serve ethnic minority populations. Most of the literature examining obesity interventions for children and adolescents is derived from samples of White, middle-class individuals (Oude Luttikhuis et al., 2009). Thus, there is uncertainty regarding how well the recommended treatment paradigms work for minority youth. Research addressing this issue directly is sparse. A recent study of a family-centered approach to addressing childhood obesity in a small sample of Latino families ($N = 26$) found that, while health-related quality of life improved when compared to controls, there was no change in BMI, metabolic health indicators, or physical activity over the course of treatment (Arauz Boudreau, Kurowski, Gonzalez, Dimond, & Oreskovic, 2013). However, the very small sample of this study is clearly a challenge to its generalizability. In contrast, another examination of a structured program with a very diverse sample of White, African American, and Hispanic youth aged 8-16 ($N = 209$) found significant reductions in BMI *z*-scores and cardiovascular indicators at the end of treatment, and one year later (Savoye et al., 2011). Finally, in a sample of 66 youth, of which 56% were from ethnic minority backgrounds, it was found that a hospital-based pediatric weight management program resulted in a small but significant reduction in BMI *z*-scores, and the intervention was

equally effective for minority and majority youth (Skelton et al., 2008). In sum, little research has addressed how well pediatric weight management programs serve youth and families from ethnic minority backgrounds, though preliminary evidence on this topic has yielded promising, but mixed results.

Another nascent area of study involves determining the effectiveness of pediatric obesity programs for other subgroups of patients. A 2001 study looking at outcomes in a small sample of 8- to 12-year-old youth with severe obesity revealed that participants experienced significant weight loss, as well as reductions in depression, anxiety, and unhealthy eating attitudes after 10 to 12 sessions of family-based group behavioral intervention (Levine, Ringham, Kalarchian, Wisniewski, & Marcus, 2001). These results were also maintained at a 4 to 13 month follow-up. A literature review of treatment studies looked at outcome differences by age, differentiating between interventions for youth under or over 12 years old (Jelalian & Saelens, 1999). These authors found that more studies have examined outcomes for children, as compared to adolescents. They also found that there is stronger evidence for effectiveness in samples under 12 years old, with most studies showing a 5 to 10% decreases in overweight. Adolescents also seem to improve after treatment, at least in the short-term. So, while outcomes for older adolescents and youth with more severe obesity are less well-studied, intervention does seem to show effectiveness for these subgroups.

In general, pediatric weight management programs seem to be effective in helping youth achieve modest, but significant reductions in BMI *z*-scores, percent overweight, and other adiposity indicators. More research is needed in order to differentiate between specific strategies that work, and those that have limited effectiveness. Early findings suggest that these interventions may be effective across ethnic minority groups, as well as across levels of obesity severity and age, though these conclusions are based on few

studies. Further investigation is also needed in order to determine what subgroups (e.g., gender and SES subgroups) of individuals are more or less likely to benefit from treatment so that interventions can be enhanced to serve all youth effectively.

Predictors of BMI Change in Pediatric Weight Management

Given the evidence for connections between mental health and pediatric obesity, it would seem that the predictive value of mental health and other variables for outcomes in pediatric obesity interventions would be an important area of inquiry. However, while a significant body of research has looked at predictors of outcomes for adults, it appears that very few studies have investigated this issue in younger samples.

The question of what variables predict success in weight management has been at least partially addressed in the adult literature. A comprehensive literature review outlined the major findings in this literature base (Teixeira et al., 2005). This review of 29 studies found that the most reliable predictors of treatment success in adults seem to be fewer prior weight loss attempts, autonomous self-motivation, and higher BMI, while eating pathology, and depression or mood problems do not tend to predict outcomes. The authors concluded that a variety of constructs have mixed evidence for predictive value, though the heterogeneity of samples, interventions, and predictive constructs used in the literature make it difficult to draw informative conclusions.

In youth, findings are even more limited. Among children and adolescents followed up after inpatient obesity treatment, the most significant predictors of weight loss at two year follow up were initial weight loss, higher baseline BMI, less disordered eating, and increased age (Braet, 2006). Interestingly, composite psychopathology scores were not significant predictors of weight loss at follow up. This study seems to indicate that age, eating disordered symptoms, and body composition are promising predictors of

weight loss, while general psychopathology plays a more limited role. Another study of inpatient adolescents with obesity looked at the predictive value of weight, psychiatric diagnoses, emotional and behavioral symptoms, and eating dysfunction at different time points across treatment. These authors found that the presence of at least one psychiatric diagnosis had inconsistent predictive value across stages of treatment, while gender and baseline BMI were more reliable predictors (Van Vlierberghe, Braet, Goossens, Rosseel, & Mels, 2009). These studies of inpatient samples provide mixed evidence for the value of psychopathology as a predictor of weight loss, with demographic variables (e.g., age) and initial BMI being more reliable predictors.

In a six-month family-based behavioral treatment for 45 8- to 11-year-old children with obesity, investigators tested the hypothesis that parent psychopathology affected treatment outcomes, mediated by child psychopathology (Epstein et al., 1994). In a path model, evidence supported the idea that parent psychopathology affects child anxiety/depression symptoms, as well as child social problems, and that these problems together impact weight loss. Interestingly, while increased social problems predicted less weight loss at 18 month follow-up, increased anxiety/depression actually predicted better outcomes, a very unexpected result (Epstein et al., 1994). Another investigation of 75 youth with obesity looked at distinguishing features of successful versus unsuccessful participants (Reinehr, Brylak, Alexy, Kersting, & Andler, 2003). These authors found that successful youth only differed in terms of previous participation in exercise groups, while other patient characteristics did not differ between groups. Several studies have drawn direct links between behavioral measures of impulsivity and poor outcomes in obesity interventions for children and adolescents (Nederkoorn, Jansen, Mulkens, & Jansen, 2006; van Egmond-Froehlich et al., 2013). Thus, research is mixed regarding

mental health predictors of outcomes in pediatric weight management, though impulsivity may reduce the effectiveness of such interventions.

Overall, little is known about which patient characteristics are associated with success in pediatric weight management. Much like the research on associations between mental health and obesity in youth, research on the value of mental health variables as predictors of weight change in these interventions is mixed. What little research there is in this area tends to be focused on adults, and may not generalize to children and adolescents. It is therefore unclear what impact mental health has on outcomes for youth. If predictors of success or failure can be identified through additional research, it will allow clinicians in charge of designing and implementing interventions to tailor their efforts and maximize the benefits for each patient.

Attrition From Pediatric Weight Management

In the assessment of effectiveness in pediatric weight management programs, attrition from treatment is a variable that is often overlooked. Although researchers usually report the number of youth who began treatment and the number who completed it, usually little else is done to evaluate what seems to be a significant issue for most pediatric weight management programs. Most studies aggregate health outcomes only for patients who completed most or all of the treatment. However, it is possible that those who drop out of treatment early receive little to no benefit from these programs, and could feasibly be harmed by the experience of treatment failure. Including these 'non-completers' in an overall assessment of how well pediatric weight management programs address the problem of rampant youth obesity reveals a major problem in need of serious response.

One challenge in interpreting the literature on attrition from pediatric weight management programs is that the definition of attrition varies from study to study. Many studies of time-limited interventions use completion of an entire treatment program as a benchmark for attrition versus retention, while studies of programs without a set number of visits vary when it comes to defining attrition (Dhaliwal et al., 2014). In order to be effective in treating obesity in youth, it is recommended that programs provide 25 or more contact hours in a six-month period (US Preventive Services Task Force, 2010). However, outpatient hospital-based pediatric weight management programs vary greatly in both the frequency and duration of service delivery (Children's Hospital Association, 2014). For these reasons, research findings surrounding attrition should be considered with the understanding that the definition of attrition is variable, and there is no universal number of sessions or treatment duration that is adhered to by programs.

Despite the variability in definitions of attrition, when defined generally as the percentage of patients who begin treatment and only complete a small portion of it before dropping out, attrition rates are quite high. Attrition rates reported across the literature on pediatric weight management programs ranged from 27 to 73 percent in one review of the literature (Skelton & Beech, 2011) and from 4 to 83 percent in another (Dhaliwal et al., 2014). Thus, in many programs fewer than half of the patients who begin treatment attend a significant number of sessions. Further, data from one large pediatric weight management clinic suggests that 37% of individual appointments are either cancelled or missed (Halvorson & Skelton, 2012). These data suggest that attrition and missed appointments are an enormous challenge facing pediatric weight management programs. Efforts to understand and address attrition should be a major focus of future research in the field of pediatric weight management.

Predictors of Attrition From Pediatric Weight Management

As a first step toward addressing the problem of attrition, it is important to identify the characteristics of programs and participants that are associated with attrition and retention. Scholars have begun to reveal these characteristics and barriers through both qualitative surveys of patients and hospitals, as well as quantitative evaluations of the associations between patient characteristics and attrition. While this area of research is relatively new, findings have started to shed light on what contributes to attrition. However, how to use this knowledge to respond to the problem largely remains to be seen.

Qualitative research, which seeks participants' views directly and in an open-ended manner, has been helpful in elucidating the reasons for the high levels of attrition in pediatric weight management programs. In a survey of families who attended two or fewer visits to such a program, 37% said the program did not meet their expectations, citing dissatisfaction with providers or the focus of treatment, though only 50% of those surveyed in this study responded to the questionnaire (Barlow & Ohlemeyer, 2006). A similar survey achieved a better response rate (74%), and found that problems with insurance and youth desire to discontinue were each cited by about half of caregivers, while 32% cited excessive time commitment (Cote et al., 2004). In these studies and others, logistical variables such as travel distance, scheduling conflicts, and problems with insurance coverage were cited by many families (Sallinen Gaffka, Frank, Hampl, Santos, & Rhodes, 2013). Finally, in surveys of hospital programs, commonly reported barriers included work and school conflicts, transportation difficulties, financial burden, and lack of benefit from the program (Hampl, Paves, Laubscher, & Eneli, 2011; Hampl et al., 2013). So, while parent and child dissatisfaction with treatment are certainly common

reasons for discontinuation, practical barriers seem to pose serious difficulties for patient retention as well.

Another important topic of study is the extent to which families leaving treatment would be willing to return. Studying this could help to reveal to what extent attrition rates could be improved with intervention. An encouraging finding is that a majority of those who have discontinued treatment may have a desire or willingness to continue intervention (Kitscha et al., 2009). Kitscha et al. (2009) also found that physical barriers (e.g., time, location, and scheduling) were most commonly cited by respondents open to returning, while unsatisfactory program content and organizational barriers (e.g., length of appointment, clinic environment) were cited most often among the 33% who said they were not willing to return to treatment. These findings suggest that many families who discontinue treatment for logistical reasons remain willing to participate in treatment, and could potentially be reengaged in interventions.

Another line of research on program attrition has examined associations between patient characteristics and attrition from pediatric weight management. A study looking at these associations found that youth who discontinued treatment tended to have lower BMI *z*-scores, were older, and had poorer school performance (Skelton et al., 2011). In another program, an overall attrition rate of 55% was observed, and higher risk of attrition was found for older youth, Medicaid recipients, and Black youth (Zeller et al., 2004). These authors cited the possibility of a "cultural mismatch" between common treatment approaches and Black families. Another study of 518 youth who began treatment replicated the finding that Black youth were more likely than youth from other ethnic backgrounds to leave treatment, though no other demographic characteristics were associated with attrition (Tershakovec & Kuppler, 2003). Interestingly, a more recent study found that, among a small sample of patients, Hispanic-identified families were less

likely to leave treatment prematurely (Faus & Leibowitz, 2015). It remains to be seen whether demographic predictors of attrition are consistent across programs, but preliminary findings suggest that, just as youth obesity rates vary across groups, so do rates of attrition.

There is some evidence that mental health variables may also predict attrition. Specifically, increased self-reported, but not parent-reported, depressive symptoms and poor self-concept seem to be associated with increased attrition (Zeller et al., 2004). Other studies that have included mental health assessments or history as predictors of attrition have not found these variables to be significant (Faus & Leibowitz, 2015; Skelton et al., 2011). Perhaps unsurprisingly, the extent to which mothers take responsibility for their adolescents' weight challenges was found be associated with patient retention, with higher sense of responsibility among mothers associated with higher retention (Joseph, Gebremariam, Gaffka, & Woolford, 2014). When it comes to psychological or mental health predictors of attrition, the findings are mixed, though youth self-reporting depressive symptoms and having low self-concept may be at increased risk of dropout.

In sum, lack of resources, including adequate time, transportation, and insurance coverage, may play a larger role in contributing to attrition than program content. Youth who are Black, older youth, and those experiencing symptoms of depression and low self-concept may be at increased risk of leaving treatment. Hispanic youth, and youth whose parents view themselves as responsible for their child's weight challenges might be less likely to drop out. In light of these findings, responding to feedback from families, addressing mental health, and improving cultural responsiveness may help to improve patient retention. In a rare intervention study aimed at reducing attrition in an 89% African American sample, simply providing a thorough orientation session before

treatment resulted in a significant reduction in attrition, which was sustained across 12 months of intervention (Germann et al., 2006). Further, many families seem to be open to returning to treatment, which bodes well for those seeking to respond to the problem of attrition (Kitscha et al., 2009). Still, continued research may help to identify additional variables that are predictive of attrition, which could in turn help in designing programs that retain more patients.

CONCLUSIONS

Childhood and adolescent obesity remains a major public health challenge in the United States. Obesity in children and adolescents is defined as a BMI score that is at or above the 95th percentile for age and sex, based on growth charts from a reference population spanning 1963-1994 (Barlow & The Expert Committee, 2007; Kuczmarski et al., 2000). Though the rate has leveled off in the last decade, obesity affects about 17% of young Americans, an alarming statistic that has been met with calls for serious intervention (Ogden et al., 2014). Unfortunately, obesity seems to be particularly prevalent among African American and Hispanic youth, whose obesity rates are 6% and 8% higher than their White peers, respectively (Ogden et al., 2014). There are likely multiple causes for disparities in obesity rates across ethnic groups, but while it is often assumed that socioeconomic status accounts for most of the difference, recent research suggests that economics alone cannot explain the discrepancies (Shih et al., 2013; Wang & Zhang, 2006).

Obesity in youth is associated with a number of physical, psychological, and social challenges. Common concurrent health problems include diabetes, sleep apnea, and orthopedic problems (Deckelbaum & Williams, 2001; Dietz & Robinson, 2005; Must & Strauss, 1999). Childhood and adolescent obesity also predicts obesity in adulthood,

and is associated with a number of cardiovascular risk factors predicting morbidity and mortality in adulthood (Dietz, 1998; Engeland, Bjørge, Tverdal, & Søgaard, 2004; Reilly et al., 2003). Youth with obesity face stigmatization from many sources (Puhl & Latner, 2007). Further, they often experience lower self-esteem and quality of life, as well as elevated levels of depression and anxiety (Buttitta et al., 2014; Erickson et al., 2000; Merikangas et al., 2012; Vila et al., 2004). Longitudinal research indicates that depression predicts later obesity, and obesity also predicts later depression (Blaine, 2008; Luppino et al., 2010). Thus, there is some evidence for a bidirectional association between mental health problems and obesity.

Similar results have been found for the associations between obesity and ADHD or externalizing problems. Youth with ADHD or externalizing problems appear more likely to have high concurrent BMI (Erhart et al., 2012; Pauli-Pott et al., 2014). Again, there is also evidence for longitudinal connections between ADHD or externalizing problems and later obesity (Duarte et al., 2010; Pine et al., 1997; von Stumm et al., 2011). Although researchers are just beginning to understand the causal mechanisms behind these associations, findings reveal that the mental health of youth may have a significant impact on the development of obesity and vice versa, which highlights the need for the integration of behavioral and psychological intervention in efforts to address the problem of childhood and adolescent obesity.

Current best practice recommendations for pediatric weight management recognize the importance of addressing psychological and behavioral factors in concert with physical health using a multidisciplinary approach (Barlow & The Expert Committee, 2007). Hospital-based pediatric weight management programs use this approach to varying degrees, supplementing nutrition and physical health interventions with behavior health components. Studies reveal that these programs can be effective in

reducing BMI and impacting other health indicators, such as cardiovascular risk factors, though these results are modest and hard-won. Further, attrition from pediatric weight management programs is a serious issue, with attrition rates ranging from 27 to 73% across programs (Skelton & Beech, 2011). Considering these facts, a serious question remains: How can programs enhance outcomes in pediatric weight management clinics, both in terms of BMI reduction and patient retention?

In order to answer this question, it is important to examine how mental health and other patient characteristics affect treatment outcomes and patient retention in pediatric weight management. The few studies on this topic suggest that variables such as depressive symptoms and self-concept, as well as practical problems such as insurance coverage, can impact attrition rates (Zeller et al., 2004). Research on how mental health and other variables influence other outcomes in treatment, such as BMI *z*-score change, are unclear. Some studies seem to indicate that mental health problems influence outcomes, while others find little association. Unfortunately, the literature on this topic is quite heterogeneous, spanning a range of programs, mental health measures, and outcome indicators, which makes it difficult to draw clear conclusions. Therefore, it is critical to pursue more research, focusing on how patient characteristics impact attrition and outcomes in real world childhood obesity interventions, using measures and patient data that are readily available to clinicians in such programs. Significant findings of such research could help in the identification of patients at risk for poor outcomes, and may guide intervention decisions to ensure that every patient has the best possible chance of success.

Appendix B: Research Questions and Hypotheses

Research Question 1: What is the overall effectiveness of the pediatric weight management program, as measured by change in patient BMI *z*-score mean and raw BMI score mean?

- Hypothesis 1: There will be a small but statistically significant decrease in BMI *z*-scores from pre- to post-treatment for patients who attended at least three, four, or five clinic appointments.
    - Rationale: Pediatric weight management programs have demonstrated effective when it comes to reducing BMI in children and adolescents at post-treatment and follow-up (Oude Luttikhuis et al., 2009). Therefore, it is expected that youth in this pediatric weight management program will show decreases in BMI *z*-scores.
    - Finding: There was an average decrease in BMI *z*-score of -.027 at the last included visit. This was statistically significant in a paired-samples *t*-test ($t(159) = 2.020$, $p = .045$). However, there was an average increase in raw BMI of .486 at their last included visit. This difference was also statistically significant in a paired-samples *t*-test ($t(162) = -3.868$, $p < .001$).

Research Question 2: What is the overall rate of attrition from the pediatric weight management program?

- Hypothesis 2: A large proportion of patients who attended an intake appointment will have discontinued treatment prior to their third or fourth clinic appointment.
    - Rationale: In previous reviews of the literature on attrition from pediatric weight management, rates of attrition were typically found to range from 27 to 73% (Skelton & Beech, 2011) in one study, and 4 to 83% in another (Dhaliwal et al., 2014). Therefore, it is expected that many youth and families who begin treatment will quickly discontinue.
    - Finding: 33.3% of patients dropped out of treatment prior to attending a third visit. 48% dropped out of treatment prior to attending a fourth visit.

Research Question 3: Do easily identified demographic variables, such as age, gender, insurance status, racial or ethnic background, and parent's preferred language predict BMI change and attrition in this sample?

- Hypothesis 3a: Age will account for a statistically significant proportion of variance in attrition, but not BMI *z*-score or raw BMI change.
    - Rationale: Evidence suggests that pediatric weight management programs are effective across age groups, though interventions for adolescents have not been studied as much as those for children (Oude Luttikhuis et al., 2009). However, risk for dropout seems to increase as youth age (Skelton & Beech, 2011; M. Zeller et al., 2004).

- Finding: Age was not a significant predictor of attrition at the third or fourth visit, nor was age a significant predictor of BMI *z*-score or raw BMI change.

- Hypothesis 3b: Gender will not account for a statistically significant proportion of variance in either attrition, BMI *z*-score change, or raw BMI change.
  - Rationale: To date, this author is unaware of studies suggesting gender differences in attrition from pediatric weight management or consistent gender differences in BMI change across treatment.
  - Finding: Gender was not a significant predictor of attrition at the third or fourth visit, nor was gender a significant predictor of BMI *z*-score change or raw BMI change.
- Hypothesis 3c: Racial or ethnic minority youth will show higher rates of attrition when compared to their majority peers.
  - Rationale: There is some evidence that ethnic minority youth are at higher risk for dropout from pediatric weight management than their White counterparts (Skelton et al., 2011; Zeller et al., 2004). BMI change in treatment does not seem to be related to ethnic background, though White, middle-class youth are disproportionately represented in the literature (Oude Luttikhuis et al., 2009).
  - Finding: Compared to majority group (White/Caucasian) peers, minority group membership (i.e., Black/African American, Hispanic/Latino, or

Other) did not significantly predict attrition at the third or fourth visit, BMI *z*-score change, or raw BMI change.

- Hypothesis 3d: Parent's preferred language will not predict attrition from pediatric weight management, but may predict BMI *z*-score or raw BMI change.
    - Rationale: Previous research has not revealed higher rates of attrition for Hispanic or Latino patients (Skelton & Beech, 2011). However, acculturation does seem to be an important predictor of feeding practices, which may in-turn affect outcomes in pediatric weight management (Kaiser et al., 2001; Wojcicki et al., 2012).
    - Finding: Parent's preferred language was a significant predictor of dropout prior to the fourth visit (Odds Ratio = .386, $P = .017$). When compared to youth whose parents who preferred English, youth whose parents preferred Spanish or both Spanish and English were less likely to drop out of the program, controlling for other variables in the model. However, parent's preferred language was not a significant predictor of BMI *z*-score change, raw BMI change, or dropout prior to the third visit.
- Hypothesis 3e: Insurance status (subsidized versus unsubsidized) will predict attrition, but will not predict BMI *z*-score or raw BMI change.
    - Rationale: Challenges with insurance and financial difficulties are often cited by parents and clinicians as reasons that families leave pediatric weight management (Barlow & Ohlemeyer, 2006; Cote et al., 2004; Hampl et al., 2011). Further, having Medicaid was found to predict higher

attrition in one study (Zeller et al., 2004). For those who stay in treatment, there does not seem to be evidence suggesting that SES affects BMI outcomes, and overall associations between SES and obesity rates are not consistent in the general population (Wang & Zhang, 2006).

- Finding: Insurance status was not a significant predictor of attrition at the third or fourth visit, nor was insurance status a significant predictor of BMI *z*-score change or raw BMI change.

Research Question 4: Does mental health, as measured by a widely available screening tool, predict BMI *z*-score change, raw BMI change, or attrition in a large, diverse sample of youth seeking treatment for obesity?

- Hypothesis 4a: Subscale scores from the PSC-17 mental health screening measure and other mental health related variables will account for a statistically significant proportion of variance in BMI *z*-score change and raw BMI change from pre- to post-treatment.
    - Rationale: Among samples of youth some evidence seems to show a relation between mental health problems, including internalizing problems or the presence of a psychiatric diagnosis, and weight change (Epstein et al., 1994; Van Vlierberghe & Braet, 2007), while other evidence does not (Braet, 2006). Further, a number of proposed causal relations between obesity and a variety of mental health variables suggest that challenges in mental health functioning may impact obesity risk, and could therefore

affect treatment outcomes (Appelhans, 2009; Liu et al., 2008; Luppino et al., 2010).

  - Finding: PSC-17 subscale scores were not found to be statistically significant predictors of either BMI *z*-score change or raw BMI change. Further, taking psychiatric medications at intake and receiving counseling through the pediatric weight management clinic were not statistically significant predictors of BMI *z*-score change or raw BMI change.

- Hypothesis 4b: Subscale scores from the PSC-17 mental health screening measure and other mental health related variables will account for a statistically significant proportion of variance in attrition from the pediatric weight management program.
  - Rationale: Though few studies have examined the relation between mental health and attrition from pediatric weight management, there is some evidence that mental health problems, specifically depression and low self-concept, may predict attrition (Zeller et al., 2004). Therefore, it is likely that subscales measuring internalizing problems will account for some of the variance in attrition in this study. It is also possible that externalizing and attention subscales will account for variance in attrition, though the literature is less clear on this topic.
  - Finding: No mental health variables were statistically significant predictors of dropout prior to the third visit. Taking psychiatric medications at intake was a significant predictor of dropout prior to the

fourth visit, (Odds Ratio = .295, *P* = .016). When compared to patients who were not taking psychiatric medication at intake, patients who were taking medication were less likely to drop out of the program before the fourth visit, controlling for other variables in the model. Parent-reported inattention on the PSC-17 was also a significant predictor of dropout prior to the fourth visit (Odds Ratio = 1.197, *P* = .037). Higher PSC-17 Attention subscale scores were associated with increased odds of dropping out prior to the fourth visit. No other included mental health variables predicted dropout prior to the fourth visit.

Appendix C: Pediatric Symptom Checklist (PSC-17) Items, English Version

1. I Feels sad, unhappy
2. Feels hopeless
3. Is down on self
4. Worries a lot
5. Seems to be having less fun
6. Fidgety, unable to sit still
7. Daydreams too much
8. Distracted easily
9. Has trouble concentrating
10. Acts as if driven by a motor
11. Fights with other children
12. Does not listen to rules
13. Does not understand other people's feelings
14. Teases others
15. Blames others for his/her troubles
16. Refuses to share
17. Takes things that do not belong to him/her

Appendix D: Pediatric Symptom Checklist (PSC-17) Items, Spanish Version

1. Se siente triste, infeliz
2. Se siente sin esperanzas
3. Se siente mal de sí mismo
4. Se preocupa mucho
5. Parece divertirse menos
6. Es inquieto(a), incapaz de sentarse tranquilo(a)
7. Sueña despierto demasiado
8. Se distrait fácilmente
9. Tiene problemas para concentrarse
10. Es muy active(a), tiene mucha energía
11. Pelea con otros niños
12. No obedece las reglas
13. No comprende los sentimientos de otros
14. Molesta o se burla de otros
15. Culpa a otros pro sus problemas
16. Se niega a compartir
17. Toma cosas que no le pertenecen

Appendix E: Attrition Sample Correlation Matrix

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Dropped By 3rd Visit	1														
2. Dropped By 4th Visit	-	1													
3. 1st Visit BMI	.040	.005	1												
4. Age	.021	-.029	-.057	1											
5. Sex	-.053	-.045	-.038	-.018	1										
6. Insurance	-.049	-.116	.121	.011	.119	1									
7. White	-.038	.053	-.134	-.024	-.159*	-.358**	1								
8. Hispanic/ Latino	-.011	-.062	-.021	.005	-.022	.409**	-.632**	1							
9. Black/AA	.029	-.012	.239**	.032	.139	-.060	-.188**	-.385**	1						
10. Other Race	.043	.040	-.013	-.007	.123	-.111	-.183*	-.374**	-.111	1					
11. Preferred Lang.	-.135	-.154*	-.079	-.040	.029	.410**	-.214**	.386**	-.243**	-.090	1				
12. Psych Meds	-.032	-.114	-.094	.105	-.073	-.157*	.027	.097	-.148*	-.049	-.140*	1			
13. PSC-17 Attn.	.034	.043	.015	-.081	-.169*	.132	.041	-.006	-.043	-.005	-.032	.248**	1		
14. PSC-17 Ext.	.040	-.034	.016	-.084	-.046	.088	-.042	.012	-.052	.096	-.004	.153*	.491**	1	
15. PSC-17 Int.	-.057	-.137	.039	.193**	.164*	-.079	-.026	-.034	.028	.067	-.173*	.337**	.345**	.313**	1

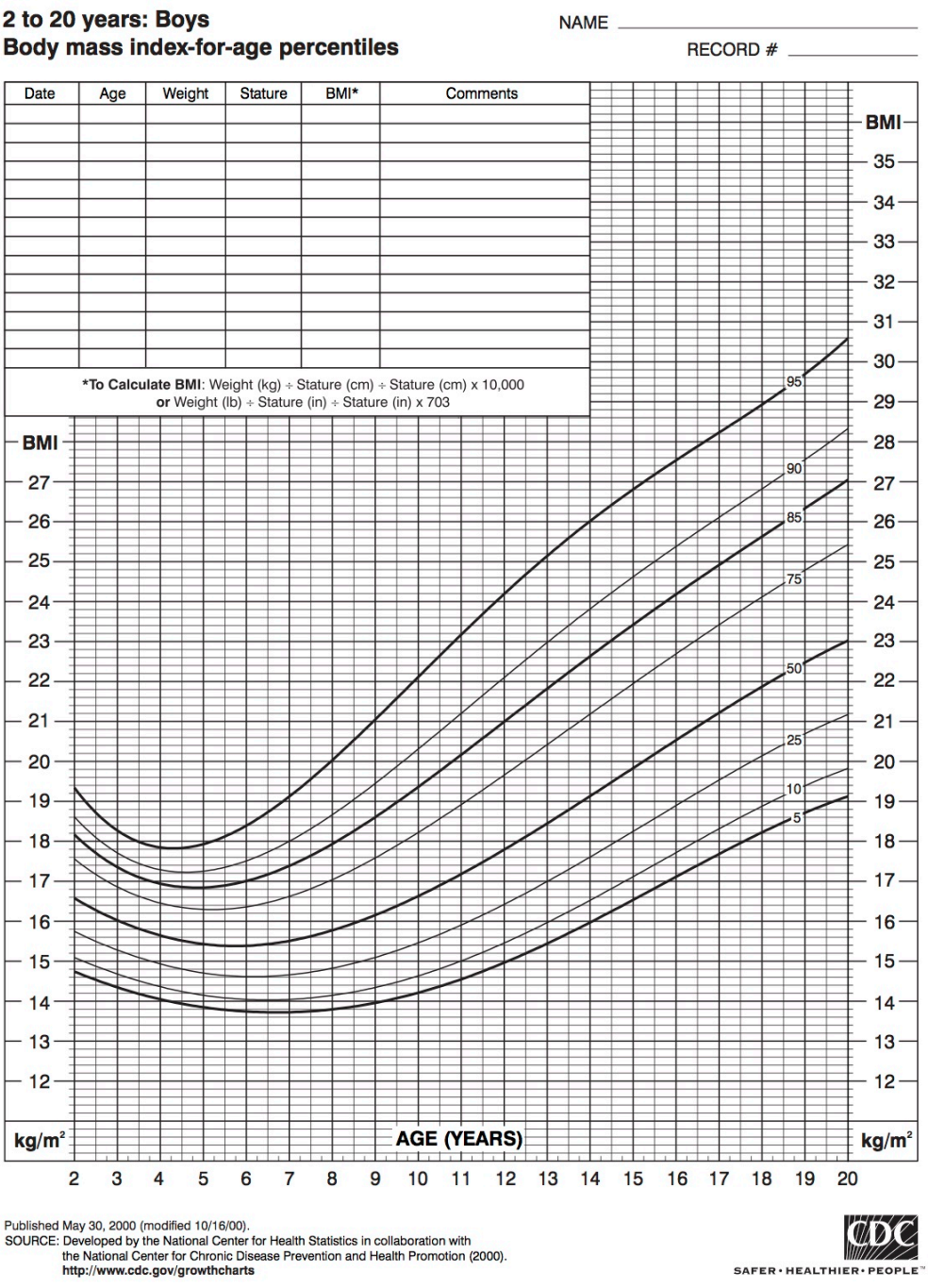
* Correlation significant at the 0.05 level (2-tailed), ** Correlation significant at the 0.01 level (2-tailed)

Appendix F: BMI Change Sample Correlation Matrix

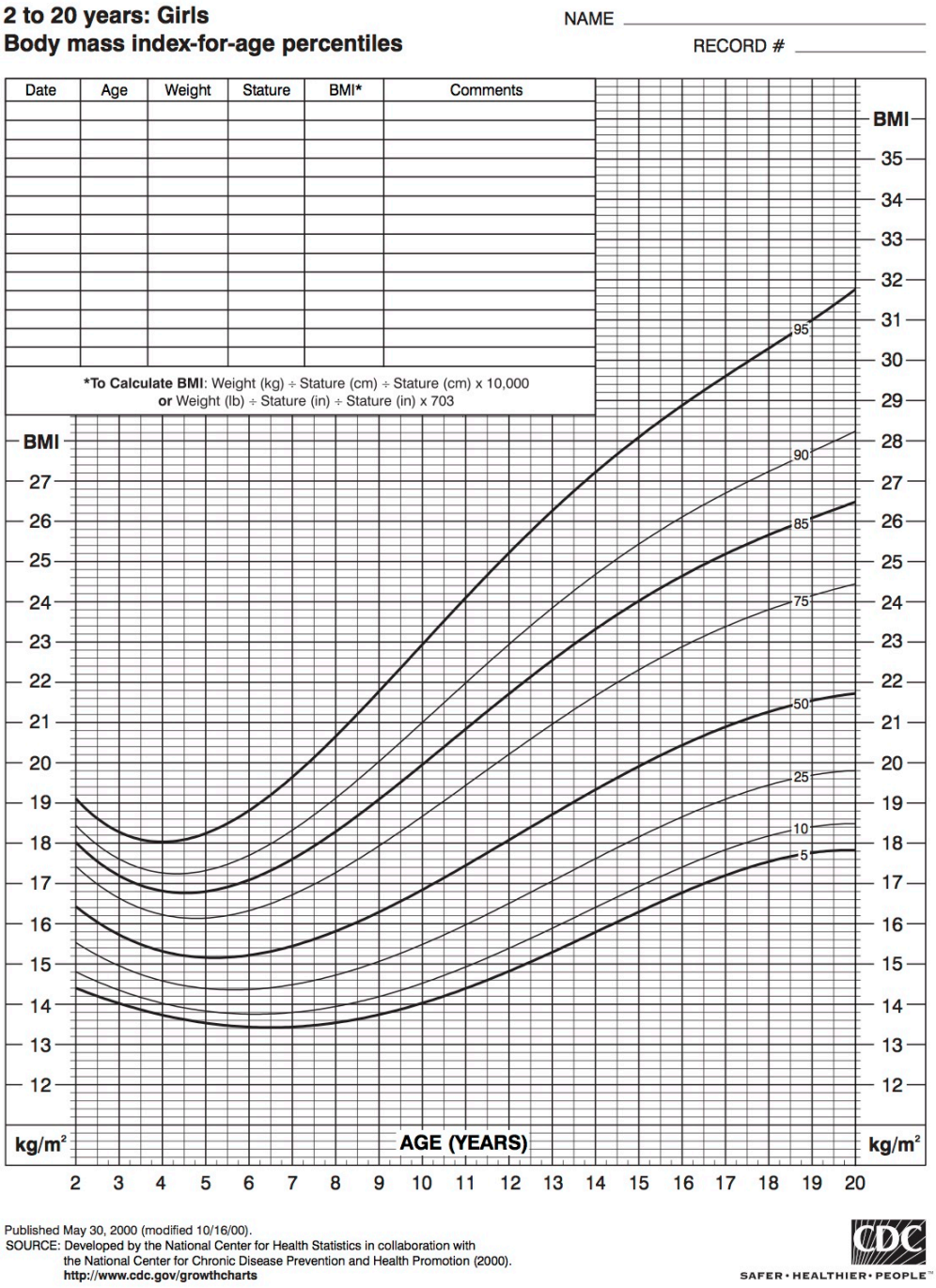
Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. BMI *z*-score Change	1																
2. Raw BMI Change	-	1															
3. Last Visit #	-.058	.167*	1														
4. Avg. Time Between Visits	.213**	.342**	.144	1													
5. Age	.137	-.017	-.003	.032	1												
6. Sex	.059	.072	-.025	-.162	.036	1											
7. Insurance	-.062	-.072	.121	.056	.061	.060	1										
8. White	.006	-.035	-.079	-.057	-.055	-.111	-.264**	1									
9. Hispanic	-.027	-.059	.183*	.107	.070	.058	.204*	-.575**	1								
10. Black/ AA	.002	.065	.027	.075	-.001	.127	-.003	-.179*	-.367**	1							
11. Other Race	.030	.070	-.195*	-.153	-.034	-.063	.024	-.211*	-.433**	-.135	1						
12. Preferred Lang.	-.031	.031	.082	.081	-.044	.013	.398**	-.151	.294**	-.277**	.000	1					
13. Couns	.007	.001	.218**	.107	.068	-.051	-.006	-.035	.154	.009	-.188*	-.052	1				
14. Psy. Meds	.055	-.012	.089	-.045	.060	-.150	-.150	-.051	.146	-.090	-.071	-.216**	.067	1			
15. PSC-17 Attn.	.041	.025	.079	.079	-.081	-.256**	.099	-.017	-.031	.025	.043	-.059	.205*	.296**	1		
16. PSC-17 Ext.	.152	.095	.051	.051	-.107	-.054	.032	-.039	.132	-.132	-.023	-.011	.255**	.159	.464**	1	
17. PSC-17 Int.	.085	.033	.034	.034	.157	.119	-.125	-.063	.107	.032	-.108	-.218**	.180*	.208*	.368**	.325**	1

* Correlation significant at the 0.05 level (2-tailed), ** Correlation significant at the 0.01 level (2-tailed)

Appendix G: CDC BMI-For-Age Growth Chart, Boys 2 to 20 Years



Appendix H: CDC BMI-For-Age Growth Chart, Girls 2 to 20 Years



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